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Biological Services Program

FWS/OBS-80/56
SEPTEMBER 1980

IMPACTS OF URANIUM MINING AND MILLING UPON THE FISH AND WILDLIFE RESOURCES OF THE NEW MEXICO SAN JUAN BASIN

Fish and Wildlife Service

U.S. Department of the Interior

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FWS/OBS-80/56
September 1980

IMPACTS OF URANIUM MINING AND MILLING UPON THE FISH AND WILDLIFE RESOURCES OF THE NEW MEXICO SAN JUAN BASIN REGION

Final Report Prepared For

San Juan Basin Regional Uranium Study
Bureau of Indian Affairs
U.S. Department of Interior

by

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INTRODUCTION

Western North America produces more metal and mineral products today than any other region of similar size in the world (U.S.D.A. Forest Service 1977). The "energy crisis" has stimulated the exploration for and development of new sources of energy. Uranium ore is one such energy source that is quite abundant in certain parts of the West (Copeland 1973). Major deposits are found throughout the Colorado Plateau, covering about 150,000 mi^2 (388,500 km^2) in parts of Colorado, Utah, Arizona, and New Mexico. The San Juan Basin, the area we are concerned with, lies within the Plateau.

The San Juan Basin, besides having an abundant supply of uranium ore, provides habitat for a diverse array of wildlife, some of which are considered rare or endangered. Little information exists on the effects of uranium mining and milling on wildlife. We will attempt to identify the species present and the available habitat that these species occupy. This will be followed by an identification of the impacts that have confronted these species with some recommendations on the approaches that could be taken to mitigate impacts and improve the wildlife habitat.

STUDY AREA

The San Juan Basin Regional Uranium Study Area covers 25,000 mi^2 (64,750 km^2) in northwestern New Mexico, northeastern Arizona, southeastern Utah, and southwestern Colorado. Elevation ranges from approximately 4300 ft (1311 m) at Bluff, Utah to over 13,000 ft (3962 m) at Summit Peak near Pagosa Springs, Colorado.

Soils of the area have been divided into four major regions. These are the light-colored soils of the cool desertic region, the moderately dark-colored soils of the plateau region, the moderately dark and dark-colored soils of the mountainous region and the light-colored soils of the warm desertic region (Rangeland Resources International, Inc. 1978). The cool desertic region lies in the Colorado Plateau physiographic province (Buchanan 1978). The general appearance of this area is that of a moderately undulating plain, broken by small mesas, hogback ridges, and a few igneous dikes. Most of the soils of this region are calcareous, poorly developed, and lack organic matter (Rangeland Resources International, Inc. 1978).

The plateau region is an area of broad mesas and plateaus interspersed with numerous deep canyons and dry washes (Buchanan 1978). Isolated volcanic peaks and cones are scattered through the region. Lava flows are a distinctive feature of this area. The soils of this region are classified as mesic (Rangeland Resources International, Inc. 1978), and many of the soil associations in this area contain large rockland components.

The mountainous region consists of mountains and valleys (Buchanan 1978). Included in this are the Zuni, Chuska, Jemez, San Juan, Nacimiento, and Cebolleta mountains and Mt. Taylor. The soils of this region were formed primarily from sedimentary rock, although in some areas soils of igneous origin are found (Rangeland Resources International, Inc. 1978).

The warm desertic region reaches into the lower portion of the study area along the Rio Grande Valley (Rangeland Resources International, Inc. 1978). Soils are classified as thermic and parent material is mostly of Quaternary origin. For a more detailed description of soils of the study area see Leven and Dregne (1963), Maker et al. (1974), Buchanan (1978), and Rangeland Resources International, Inc. (1978).

Table 1 lists the average annual precipitation and temperatures of selected locations on the study area in 1977. Average annual precipitation ranges from 4-25 inches (10.1-63.5 cm), depending on and increasing with elevation (Ferrill 1978).

There are many different temperature regimes and extremes within the study area (Ferrill 1978). In the higher mountains some areas have temperatures below the freezing point most of the time, while in the Chaco and San Juan River Valleys there are protracted summer periods of daytime temperatures above 90°F (32°C).

Vegetation, for the purposes of this study, has been delineated into broad habitat types which, usually, support distinct wildlife species. Vegetation or habitat types discussed generally correspond with the vegetation

Table 1. Mean annual temperature and precipitation at various locations on the San Juan Basin Regional Uranium Study Area, 1977[a].

Location - elevation (ft)	Temperature (°F)	Precipitation (in)
Abiquiu Dam, NM - 6380	51.1	10.63
Aztec Ruins National Monument, NM - 5640	50.3	7.53
Bloomfield, NM - 5794	54.6	7.61
Chaco Canyon National Monument, NM - 6175	49.7	7.35
Chama, NM - 7850	41.9	17.93
Cuba, NM - 7045	-	12.63
Dulce, NM - 6950	44.9	15.62
El Morro National Monument, NM - 7225	47.9	17.67
Farmington, NM - 5635	-	6.73
Fruitland, NM - 5145	52.4	5.09
Gallup, NM - 6468	49.4	9.06
Grants Airport, NM - 6520	49.8	9.20
Lybrook, NM - 7150	43.3	7.70
Shiprock, NM - 4870	-	4.25
Star Lake, NM - 6640	48.3	6.83
Thoreau, NM - 7100	51.3	8.69
Tierra Amarilla, NM - 7425	44.0	15.90
Tohatchi, NM - 6420	50.8	6.86
Zuni NM - 6450	50.8	10.40
Lukachukai, Ariz. - 6520	-	6.30
Teec Nos Pos, Ariz. - 5290	54.9	5.60
Window Rock, Ariz. - 6755	-	10.00
Durango, Colo. - 6600	48.1	11.17
Mesa Verde National Park, Colo. - 7070	-	9.78
Pagosa Springs, Colo. - 7840	-	16.10
Aneth Plant, Utah - 4620	56.5	5.58
Bluff, Utah - 4315	53.3	5.68

[a]Data obtained fron National Oceanic and Atmospheric Administration (1977a,b,c,d).

types of Rangeland Resources International, Inc. (1978), although in some instances slight modifications have been made. Bailey (1932), Oosting (1958), Springfield (1976), Kinsky (1977), and Hubbard (1978) have also been used as references to vegetation types.

GRASSLAND-DESERT SHRUB

This habitat covers more area than any other vegetation type within the study area (approximately 43% of the total area). Elevation ranges from approximately 4000-7500 ft (1219-2286 m). Blue grama[1] and galleta are the most important grasses of this habitat type. Indian rice-grass, bottlebrush squirreltail, ring muhly, sand dropseed, and alkali sacaton are common. Aster, pingue, globemallow, Rocky Mountain beeweed, and Russian thistle are common forbs.

Important shrubs of this habitat type include fourwing saltbush, broom snakeweed, and rubber rabbitbrush. Big sagebrush dominates a large portion of the northcentral portion of the study area.

PINYON-JUNIPER WOODLAND

The pinyon-juniper type is generally found at elevations of 5000-7500 ft (1524-2286 m). The dominant species are pinyon pine and one-seed juniper; occasionally one or the other may not be present. In some areas singleleaf pinyon, Utah juniper, alligator juniper, or Rocky Mountain juniper also occur and in some cases may be the predominate species.

Shrubs found within the pinyon-juniper type include big sagebrush, Utah serviceberry, bitterbrush, mountain-mahogany, cliffrose, Gambel oak, and wavyleaf oak.

Blue grama, galleta, ring muhly, slim tridens, and New Mexico feathergrass are common grasses. Important forbs found in the pinyon-juniper zone include fleabane, buckwheat, pingue, bitterweed, and aster.

PONDEROSA PINE

This vegetation type is restricted to elevations of approximately 7000-9500 ft (2134-2896 m), covering the upper slopes and tops of many lower mountains. Within the study area this type can be found in the Chuska, Zuni, Jemez, San Juan, Nacimiento, and Cebolleta mountains and the Mt. Taylor area.

The dominant species of this habitat type is ponderosa pine which often occurs in pure stands. Mixed stands, in which ponderosa pine is the principal overstory component, may contain Engelmann spruce, blue spruce, white fir, subalpine fir, Douglas-fir, limber pine, quaking aspen, junipers, and Gambel oak.

[1]See Appendix for common and scientific names of all plants and animals mentioned in this report.

Principal shrubs are Utah serviceberry, squaw currant, and skunkbush sumac.

Grasses found in this type are blue grama, mountain muhly, Arizona fescue, muttongrass, junegrass, bottlebrush squirreltail, and pine dropseed. Some of the forbs found in this type are bladderpod, pingue, lupine, beardlip penstemon, and beardtongue.

MIXED CONIFER

Limited to elevations of approximately 8500-12000 ft (2591-3658 m), typical tree species of this habitat type include Douglas-fir, white fir, subalpine fir, blue spruce, Engelmann spruce, and limber pine. Quaking aspen and Gambel oak are occasionally found in this type. Important grasses are Arizona fescue, muttongrass, inland bluegrass, and oat grass.

ALPINE TUNDRA

This vegetation type occurs in high mountains above timberline in the northern part of the study area. In areas with favorable soils and moisture, bluegrasses, fescues, and sedges are common. Willows and blueberries are present, particularly in boggy areas. Important forbs are cinquefoil and buttercup. In rocky areas lichen and moss species are dominant with some vascular plants occurring where soil accumulations are greatest.

RIPARIAN

This habitat type occurs along stream and river channels where the water table is high enough to support species such as Rio Grande cottonwood, narrow-leaf cottonwood, Russian olive, coyote willow, peachleaf willow, Pacific willow, box elder, and salt cedar.

Marshy areas support plants such as cattail, horsetail, spikerush, bulrush, and sedge.

Typical grasses are Kentucky bluegrass, streambank wheatgrass, Canada wildrye, and foxtail barley. Other plants found in this habitat type include woody vines, such as Virginia creeper and virginbower, and forbs such as aster, sunflower, and Russian thistle.

METHODS

WILDLIFE

A thorough literature review and interviews with personnel of various natrual resource agencies were conducted to gather information on species distribution and the impacts of uranium mining and milling upon wildlife.

Uranium mine and mill sites were visited in June, July, and August 1979. Within a 0.5 mile (0.8 km) radius of each mine a wildlife "census" route was walked, beginning at sunrise. Wildlife species or sign observed and the habitat they utilized were recorded. Observations were also made at mill tailings ponds for wildlife use.

HABITAT ANALYSIS

Step-point transects, at least one in each vegetation type within the 0.5 mi (0.8 km) radius of the mine, were used at each site to analyze vegetation. Bare ground, litter (persistent[2] or nonpersistent), gravel (< 3 inches or 7.62 cm diameter), cobble (3-10 inches or 7.62-25.4 cm diameter), stone (> 10 inches or 25.4 cm diameter), bedrock, or plant species was recorded for each point, there being 100 points per transect. If bare ground, litter, gravel, cobble, stone, or bedrock was recorded the nearest plant species within 180° of the point was also recorded. These data were used to calculate percent ground cover and species composition.

At every 10 points, the age (seedling, young, mature), height of surrounding vegetation, and density or basal area (trees) were described. Three concentric plots were used to characterize vegetation. Trees were characterized in 0.1 acre (0.04 ha) plots, shrubs in 0.01 acre (0.004 ha) plots, and grasses and forbs in 0.0002 acre (0.00009 ha) plots. If more than five plants of a species of tree or shrub occurred within a plot, only the first five plants closest to a point chosen at random were used for characterization. Tree height was measured with a clinometer and tree basal area with a 10-factor prism. The importance value index as described by Curtis and McIntosh (1951) was calculated using these data.

[2]Persistent litter is that which would last 2 years or more, such as woody material or large animal droppings. Nonpersistent litter is that judged to last less than 2 years.

MAMMALS

Ninety-nine species of mammals are known to occur in the inventory area. The following discussion associates a species with its habitat, i.e., that particular vegetation type in which the animal carries out its daily activities. Those species that occur in more than one habitat are discussed as being associated with the habitat they most prefer. Species are discussed by order.

Appendix Table A1 lists species known to occur in the area and the habitats in which they occur. Pertinent references on other aspects of the ecology of some species are introduced to enable the reader to become more familiar with these animals.

INSECTIVORE

Six species of insectivores occur within the inventory area. The masked shrew and the vagrant shrew are found in similar habitats, both preferring moist, streamside communities in the ponderosa pine and mixed conifer types (Armstrong 1972, Findley et al. 1975). Armstrong (1972) stated that the masked shrew is not found in southwest Colorado south of the Uncomphagre Plateau and west of the San Juan Mountains. Clothier (1955) reports on the life history of the vagrant shrew.

The dwarf shrew is supposedly restricted to the mixed conifer and alpine zones (Findley et al. 1975), but Armstrong (1972) cites a specimen taken at 5500 ft (1967 m) in Colorado. The dwarf shrew occupies drier sites than the masked and vagrant shrews (Spencer and Pettus 1966).

The habitat of the Merriam shrew ranges from grassland-desert shrub and pinyon-juniper (Armstrong 1972) to the mixed conifer zone (Findley et al. 1975). In New Mexico all known specimens have been taken in the mixed conifer zone. Armstrong and Jones (1971) discuss the natural history of this species.

The northern water shrew is always found near water, most commonly in mixed conifer forests (Armstrong 1972). However, it may range into ponderosa pine forests or lower. These animals are semi-aquatic and are excellent swimmers. Conaway (1952) discussed this shrew's life history.

The desert shrew is an inhabitant of arid areas (Findley et al. 1975). However, specimens have been found in ponderosa pine forest as high as 6300 ft (1920 m) in New Mexico (Lindeborg 1960). Cockrum (1978) states that the desert shrew is widely distributed below 6000 ft (1829 m), especially in riparian situations.

CHIROPTERA

The literature records 16 species of bats as occurring within the inventory area. They are found in all habitat types, but most are limited to areas with permanent water sources. All are considered to be insectivorous, although the pallid bat has been known to feed on lizards (Vaughn 1972).

Many species of bats are seasonal migrants, but the detailed migratory patterns of most species remains to be learned (Armstrong 1972). Three species: the small-footed myotis, big brown bat, and the western big-eared bat, are definitely known to hibernate in Colorado (Armstrong 1972). Several other species, among them other Myotis, the western pipistrel, and the pallid bat, probably overwinter in the study area also. The silver-haired bat and the hoary bat have exhibited sexual differences in their migratory patterns. Males summer within the study area but females do not (Armstrong 1972, Findley et al. 1975).

The Yuma myotis occurs in the grassland-desert shrub and pinyon-juniper types and the riparian communities of these habitats (Findley et al. 1975). The little brown myotis occurs in all habitat types in the study area. Findley et al. (1975) states that vegetation type is unimportant in determining distribution of this species. The proximity of large, permanent water sources is the determining factor. Davis and Barbour (1970) recorded life history data for this species. The long-eared myotis appears to be a resident of the ponderosa pine and mixed conifer zones near permanent water.

The fringed myotis, California myotis, and western pipistrel occupy similar habitat. All are found in grassland-desert shrub, pinyon-juniper, ponderosa pine, and riparian communities of these types (Findley et al. 1975). The California myotis and western pipistrel seem to be dependent upon cliffs and rocky areas for shelter.

The long-legged myotis, small-footed myotis, and the silver-haired bat are found in all vegetation types in the study area, but are most common in the ponderosa pine zone or above (Findley et al. 1975). The small-footed myotis, like the California myotis and the western pipistrel, is an inhabitant of rock cliffs or caves. The silver-haired bat is most often considered to be a tree bat. Drueker (1972) detailed reproduction in the silver-haired bat.

The big brown bat is most common in ponderosa pine forests, but has also been recorded in the pinyon-juniper and mixed conifer forests (Findley et al. 1975). Black (1972) studied the food habits of this species and the hoary bat in New Mexico. The hoary bat is most frequently found in pinyon-juniper habitat.

The spotted bat and western big-eared bat inhabit pinyon-juniper and ponderosa pine forests (Findley et al. 1975). Rock cliffs appear to be an essential component of the habitat for both bats. See Snow (1974) for a comprehensive review of spotted bat literature.

The pallid bat is a desert species and may be found even in the absence of water or rocky terrain (Findley et al. 1975). Geluso (1972) has shown that pallid bats are physiologically specialized for life in desert regions through a modification of the kidneys and the ability to concentrate urine to a greater extent than other bats.

The Mexican free-tail bat and the big free-tail bat have approximately the same ecological distribution, with most occurring in the pinyon-juniper or grassland-desert shrub types (Findley et al. 1975). They also inhabit ponderosa pine forests up to 8200 ft (2795 m). The big free-tail is less common than the Mexican free-tail.

CARNIVORA

Eighteen species of carnivores inhabit the study area. Among these, the black bear and mountain lion are classified as game animals. The black bear is found throughout the wooded portions (Lee 1967, Armstrong 1972) and occasionally above timberline. The mountain lion prefers rimrock and timbered areas (Berghofer 1967, Findley et al. 1975), but can be found in all habitats. Kinsky (1977) reports one as being sighted in the Chaco Canyon National Monument area by Park Service personnel. Hornocker (1970) reported on the ecology of mountain lion predation and Seidensticker et al. (1973) discussed social organization of mountain lions.

Bobcats are found in all habitats, but are rare at high elevations (mixed conifer and alpine) (Berghofer 1967). The bobcat prefers rimrock country. Young (1978) discussed the various aspects of bobcat ecology.

The badger is a common species particularly in the grassland-desert shrub habitat (Findley et al. 1975). They also occur in other nonforested areas including alpine meadows.

The coyote is the most common carnivore (Kinsky 1977). It prefers the grassland-desert shrub habitat but is found in all vegetation zones including the alpine tundra (Findley et al. 1975). The coyote is an important predator and has been the object of numerous predator control programs (Cain et al. 1972, DeLorenzo and Howard 1976, Nesse et al. 1976). See Connolly and Longhurst (1975) and Young and Jackson (1978) for more information about coyotes.

The kit fox is a grassland-desert shrub species; the gray fox prefers pinyon-juniper woodland (Findley et al. 1975). The red fox is primarily an animal of wooded regions, occurring in the San Juan Valley, the pinyon-juniper type of Largo Canyon, and in southwest Colorado. See Snow (1973a) and Storm et al. (1976) for more information on the kit and red foxes, respectively.

Three species of skunks occur on the study area. Striped skunks are found in all habitats, including agricultural areas (Findley et al. 1975). They are most common in grassy areas and woodland. Spotted skunks are inhabitants of rocky and brushy areas in the grassland-desert shrub and woodland areas. The hog-nosed skunk's range extends into the southern part of the study area. Hooper (1941) records this species as occurring in Valenica County, New Mexico. The hog-nosed skunk prefers grassland-desert shrub habitat.

The ringtail occurs in rocky terrain in the grassland-desert shrub and pinyon-juniper types (Armstrong 1072, Findley et al. 1975). Raccoons can be found near permanent water courses in all habitats, and in grassland-desert shrub areas far from natural water.

The marten is restricted to the mixed conifer forest and marginal alpine habitat (Armstrong 1972, Findley et al. 1975). The marten is considered endangered (State) in New Mexico (Group II) (see endangered species section).

The shorttail weasel is also an animal of high elevation (mixed conifer) forests, where it is associated with the microtine rodent populations of

mountain meadows (Findley et al. 1975). The longtail weasel has a broad ecological distribution, occurring from desert to alpine zones (Armstrong 1972, Findley et al. 1975). Kinsky (1977) stated that this species prefers pinyon-juniper habitat.

The black-footed ferret is a resident of prairie dog towns, and consequently of grassland areas (Findley et al. 1975). This species is endangered (U.S.D.I. Fish and Wildlife Service 1979) and has not been sighted within the study area in recent years (see endangered species section).

The mink is found in the San Juan-Animas drainage in New Mexico (Findley et al. 1975) and is reported from southwestern Colorado (Armstrong 1972). In all situations, it is limited to areas of permanent water. Although the mink is considered common throughout much of its historic range, it is on the endangered species list of New Mexico (Group II) (Hubbard et al. 1978) (see endangered species section).

RODENTIA

Forty-four species of native rodents and two Old World rodents are known to occur within the study area. Rodents greatly outnumber the other orders of mammals, both in terms of individuals and number of species. Because their home ranges are relatively small, rodents are more restricted to specific habitat types than are the larger, more mobile species (Kinsky 1977).

Three species are restricted to areas of permanent water: the muskrat, meadow vole, and the beaver. Muskrats occur in marshes and drainage ditches along the San Juan River (Findley et al. 1975), in tributaries of the upper San Jose near Grants (Hooper 1941), in the Chama drainage, and in the Dolores River Basin. Armstrong (1972) states that in Colorado they occur to elevations of more than 11,000 ft (3749 m).

The meadow vole is a hydrosere species limited to grass-sedge communities near permanent water as high as 10,000 ft (3408 m) (Findley et al. 1975).

Due to uncontrolled trapping, the beaver was nearly exterminated by the end of the 19th Centrury (Huey 1956, Armstrong 1972, Findley et al. 1975). Steps were then taken by the various States to restore the animal to its range. Today, the beaver can be found in all major watercourses of the study area and in every vegetation type. Regulated trapping has been permitted since 1953 in New Mexico (Berghofer 1967) and 1958 in Colorado (Armstrong 1972). According to Cockrum (1960), the beaver does not range into the Arizona part of the study area. Huey (1956) discusses certain aspects of beaver ecology in New Mexico.

Rodents typically found in the grassland-desert shrub zone include the spotted ground squirrel, thirteen-lined ground squirrel, whitetail antelope squirrel, pocket mice, the kangaroo rats, the northern grasshopper mouse, the white-footed mouse, the southern plains woodrat, and the whitetail prairie dog (Armstrong 1972, Findley et al. 1975, Kinsky 1977). Some of these animals are also found in other habitats (Appendix Table A1). The whitetail prairie dog, while it is most common in the grassland-desert shrub zone, is often found in parks and meadows of montane forests up to 12,000 ft (4090 m, Armstrong 1972).

The thirteen-lined ground squirrel is a grassland species that has been reported from only one place on the study area; near Tierra Amarilla, New Mexico (Findley et al. 1975).

Those species of rodents which generally prefer pinyon-juniper habitat are the cliff chipmunk, the canyon mouse, pinyon mouse, rock mouse, and Stephen's woodrat (Armstrong 1972, Findley et al. 1975). The pinyon mouse is probably the most common mammal in open pinyon-juniper stands (Findley et al. 1975). The pinyon mouse is replaced by the brush mouse (Wilson 1968) where deciduous shrubs are common. The deer mouse replaces the pinyon mouse in the montane forests.

Rodents commonly found in the ponderosa pine zone include the Colorado chipmunk, golden-mantled ground squirrel, tassel-eared squirrel, mountain vole, and the Mexican vole (Armstrong 1972, Findley et al. 1975). The tassel-eared squirrel is unique because its life necessities are almost entirely furnished by a single plant - the ponderosa pine (Keith 1965, Patton 1977). See other reports by Patton (1974a, 1975) and Rasmussen et al. (1975) on food consumption and home range of this species. The tassel-eared squirrel is a game species in New Mexico, Colorado, and Arizona, but is protected on the Navajo Indian Reservation.

The mixed conifer forest is the preferred habitat of the least chipmunk, red squirrel, northern pocket gopher, Mexican woodrat, bushytail woodrat, boreal redback vole, mountain phenacomys, longtail vole, and the western jumping mouse (Armstrong 1972, Findley et al. 1975).

The red squirrel seems to be especially fond of blue spruce (Findley et al. 1975). Armstrong (1972) stated that generally only dense stands of lodgepole pine, Douglas-fir, spruces, and firs support large populations, but some are found outside this vegetation zone. Some have even been observed in cottonwoods. The red squirrel is a game species in New Mexico and Colorado. Western jumping mice inhabit mesic meadows, usually in the higher montane forests (Findley et al. 1975). This species is often associated with streamside willow communities and the grass-forb understory of mature quaking aspen stands (Armstrong 1972).

The porcupine is primarily an animal of coniferous forests (Armstrong 1972, Findley et al. 1975), although they are also found in grassland-desert shrub and alpine habitats. Porcupines feed on various plant materials, including the inner bark of trees, particularly conifers. Damage to trees may be considerable, lowering the value of timber and damaging orchards (Armstrong 1972).

The yellowbelly marmot appears to prefer alpine habitat, but is also found in meadows of the mixed conifer forest down to approximately 10,000 ft (3408 m) (Findley et al. 1975). Rock slides and boulder piles are favorite areas. Durrant and Dean (1961) and Harris (1963) recorded them at 5980 ft (2038 m) in northeastern San Juan County, New Mexico, in pinyon-juniper woodland.

Examples of habitat generalists are the rock squirrel, valley pocket gopher, western harvest mouse, and the whitethroat woodrat. The valley pocket gopher occupies every habitat where suitable soil conditions occur except at

high elevations (Findley et al. 1975). Rock squirrels depend on broken, rocky terrain and occupy such areas in all habitat except the highest montane forests. Western harvest mice are found in all habitats except well developed mixed coniferous forests. The whitethroated woodrat is common in all habitats except the alpine tundra.

Two non-native rodents, the house mouse and the Norway rat, are found within the study area. Both are closely associated with man and are likely to occur in or near any area of human inhabitation. House mice are widespread and have the distribution of a typical grassland rodent (Fi- et al. 1975). Howard and Marsh (1976) show the Norway rat occurring in a and Bailey (1932) stated that the Norway rats were found in all the settlements" of New Mexico as early as 1851. Armstrong (1972), howev s that this species does not occur widely, if at all, on the western the Rockies in Colorado.

LAGOMORPHA

Within the inventory area this order is represented by two families and three genera. The pika occurs typically near or above timberline (Armstrong 1972, Findley et al. 1975). Talus slopes are the preferred habitat. Johnson and Maxell (1966) have described the food habits of the pika in the San Juan Mountains of Colorado.

The snowshoe hare is an inhabitant of the mixed coniferous forest (Armstrong 1972, Findley et al. 1975). Seral vegetation of this forest type provides the favored habitat. Dolbeer and Clark (1975) and Keith and Windberg (1978) report on the population dynamics of this species.

The whitetail jackrabbit occurs from open mountain parkland to well above timberline in the northeast part of the study area (Armstrong 1972, Findley et al. 1975). Bear and Hansen (1966) describe the autecology of this species.

The blacktail jackrabbit is found in the lower vegetational zones, although occasionally it is observed in ponderosa pine as high as 8700 ft (2965 m) (Findley et al. 1975). The largest populations are found in the grassland-desert shrub type. Gross et al. (1974) studied the demography of this species in Utah, and Griffing and Davis (1976) report on other aspects of the blacktail jackrabbit's ecology and biology.

Three species of cottontails occur on the study area (Armstrong 1972, Findley et al. 1975). The desert cottontail occurs in the grassland-desert shrub and pinyon-juniper habitats. The eastern cottontail is found only on Mt. Taylor and in the Zuni Mountain portion of the study area in the pinyon-juniper and ponderosa pine types. The mountain cottontail ranges in the northern part of the study area. It inhabits edge situations in forests at moderate elevations (Armstrong 1972). Harris (1963) stated it is found primarily in "ponderosa pine-Douglas-fir forests," but also occurs in riparian vegetation along Pine River in northern New Mexico. See Ingles (1941), Fitch (1947), Powers and Verts (1971), Jacobson et al. (1978), and McKay and Verts (1978) for more on cottontails.

ARTIODACTYLA

At least five, possibly seven, species of this order can be found within the inventory area: mule deer, whitetail deer, elk, pronghorn, bighorn sheep, Barbary sheep, and tahr.

The mule deer is the most widely distributed and most common big game animal found within the study area. They can be found in all habitats and at all elevations, but greatest densities occur in the pinyon-juniper and ponderosa pine types. Mule deer do best in areas where a diversity of successional stages of vegetation exist. The most productive mule deer ranges consist of seral vegetation, resulting from fire, logging, and livestock grazing (Hill 1956).

Within the study area, heaviest concentrations of mule deer can be found in the Chuska Mountains, the Mt. Taylor area, and in the northcentral part of the study area, from Farmington east to and including the Jicarilla Apache Reservation (Figure 1).

Over 90% of the deer on the Navajo Indian Reservation are in the Chuska Mountains (J. Antonio[3] 1978, personal communication). This small mountain range provides a variety of habitats from grassland-desert shrub to mixed conifer at higher elevations. Navajo Fish and Wildlife at Window Rock, Arizona considers the east side of the Chuskas to be key deer winter range.

The Mt. Taylor area, particularly Cibola National Forest, supports a relatively large deer herd. San Mateo Mesa, the La Jara Mesa area, and both the northeast and northwest sides of Cibola National Forest are key wintering areas for mule deer (Figure 1). Rinconada Canyon (Cibola National Forest) is considered to be key habitat for deer, as well as elk and wild turkey. A key deer wintering area is also located on U.S.D.I. Bureau of Land Management land south of Interstate 40 between Thoreau and Gallup. This is the area drained by Four Mile, Smith, and Whitewater Canyons.

The La Ventana, Ignacio Chavez, and Continental Divide areas are also considered key deer winter habitat.

Most of the pinyon-juniper habitat in the northcentral portion of the study area supports both resident and migrant mule deer. Highest densities are found in the eastern portion of the Carson National Forest and north of the San Juan River (New Mexico Department of Game and Fish 1979a).

National Resource lands along the San Juan, Animas, and La Plata rivers support year-round resident deer herds (Kinsky 1977). Livestock grazing has been eliminated from these areas and they provide good habitat for deer and other wildlife.

[3]Navajo Fish and Wildlife, Window Rock, Arizona.

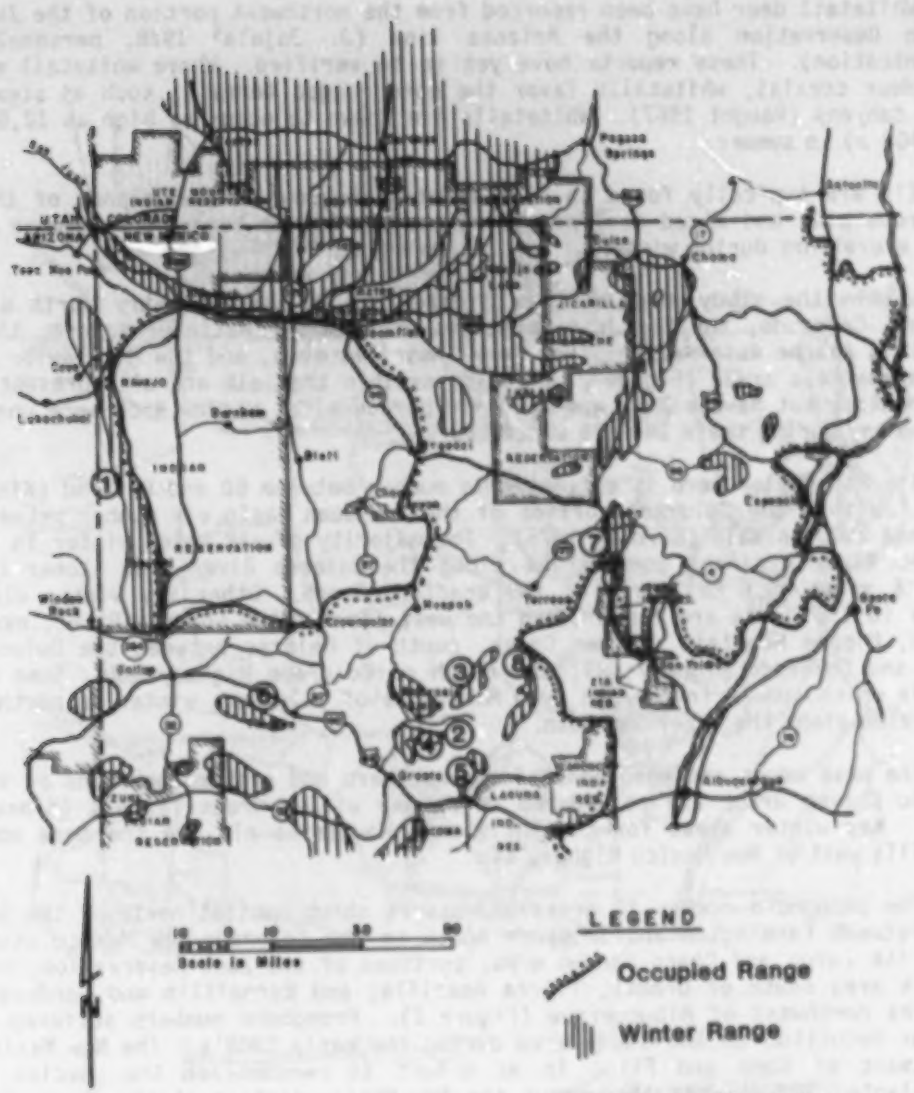

Figure 1. Mule deer range, San Juan Basin Regional Uranium Study Area. (Sources: New Mexico Department of Game and Fish, Colorado Division of Wildlife, Navajo Fish and Wildlife).

Whitetail deer have been reported from the northwest portion of the Zuni Indian Reservation along the Arizona line (J. Jojola[4] 1978, personal communication). These reports have yet to be verified. Where whitetail and mule deer coexist, whitetails favor the more rugged terrain, such as steep, rocky canyons (Raught 1967). Whitetails are known to occur as high as 10,000 ft (3408 m) in summer.

Elk are typically found in high mountain meadows and woodlands of the ponderosa pine and mixed conifer types, and the alpine tundra. They move to lower elevations during winter.

Within the study area elk are limited to the high country north of Dolores, Colorado, the San Juan Mountains, the Carson National Forest, the Jicarilla Apache Reservation, the Tierra Amarilla area, and the Mt. Taylor and La Ventana Mesa areas (Figure 2). It is possible that elk are also present in the Chuskas, but Navajo Fish and Wildlife personnel at Window Rock were unable to find any during their 1978-79 winter survey.

The Mt. Taylor herd is estimated to number between 60 and 80 head (Kinsky 1977). Within the Colorado portion of the San Juan Basin elk number between 1700 and 2000 animals (Burdick 1976). The majority of elk which winter in the Dolores River drainage concentrate along the Dolores River from Stoner to about 6 miles (9.6 km) north of the Bradford Ranch. Other key winter elk ranges in this area are found along the west fork of the Dolores River, near Dutton, Nipple Mountain, Stoner Creek, south of Dolores between the Dolores River and Colorado Highway 184, and north of Colorado Highway 160. Some of the elk which summer in the San Juan Mountains of Colorado, winter in northern New Mexico along the upper San Juan.

The mesa edges and woodlands of the northern and eastern portions of the Ignacio Chavez Grant are considered to be key winter areas for elk (Kinsky 1977). Key winter areas for the Nacimiento Mountains elk are the mesa and foothills east of New Mexico Highway 44.

The pronghorn occurs in grassland-desert shrub habitat north of the San Juan between Farmington and Shiprock north to the Colorado-New Mexico state line; the Largo and Chaco canyon area; portions of the Zuni Reservation; the Malpais area south of Grants, Tierra Amarilla; and Bernalillo and Sandoval counties northwest of Albuquerque (Figure 3). Pronghorn numbers suffered a serious reduction on the study area during the early 1900's. The New Mexico Department of Game and Fish, in an effort to reestablish the species, transplanted 722 animals throughout the New Mexico portion of the study area between 1932 and 1967. These attempts were, for the most part, unsuccessful. Howard et al. (1973) believed that pronghorn numbers in south-central New Mexico are restricted by the limited amount of suitable habitat and low densities of shrubs and forbs. This may apply to the study area also, although research would be needed to make definite statements. See Kitchen (1974) for an analysis of pronghorn behavior.

Within the study area, bighorn sheep are found only in Mesa Verde National Park and the San Juan Mountains in the northeastern corner of Montezuma County, Colorado (Armstrong 2972, Colorado Division of Wildlife 1974). Approximately 25-30 sheep inhabit Mesa Verde National Park. Bighorn

[4]U.S. Fish and Wildlife Service, Gallup, N.M.

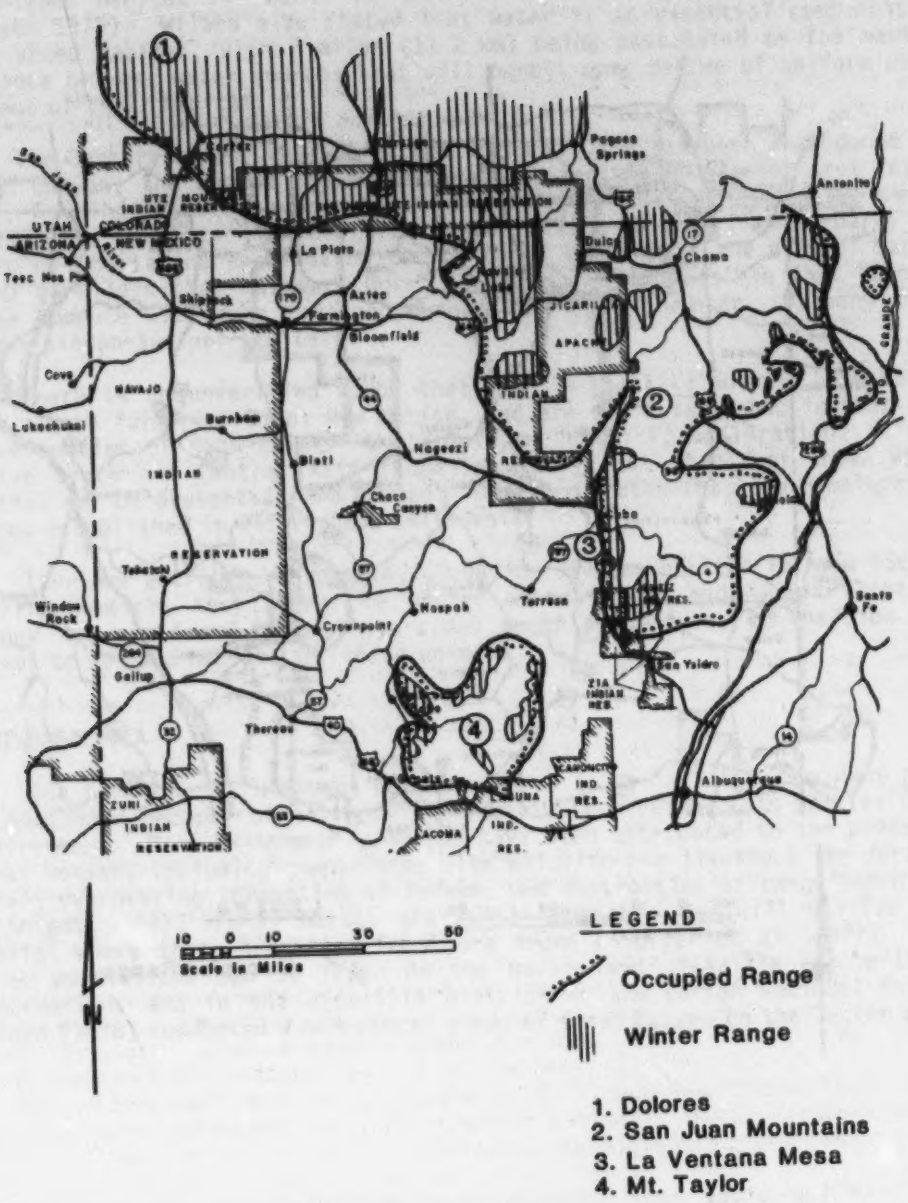

Figure 2. Elk range, San Juan Basin Regional Uranium Study Area. (Sources: New Mexico Department of Game and Fish, Colorado Division of Wildlife, Navajo Fish and Wildlife).

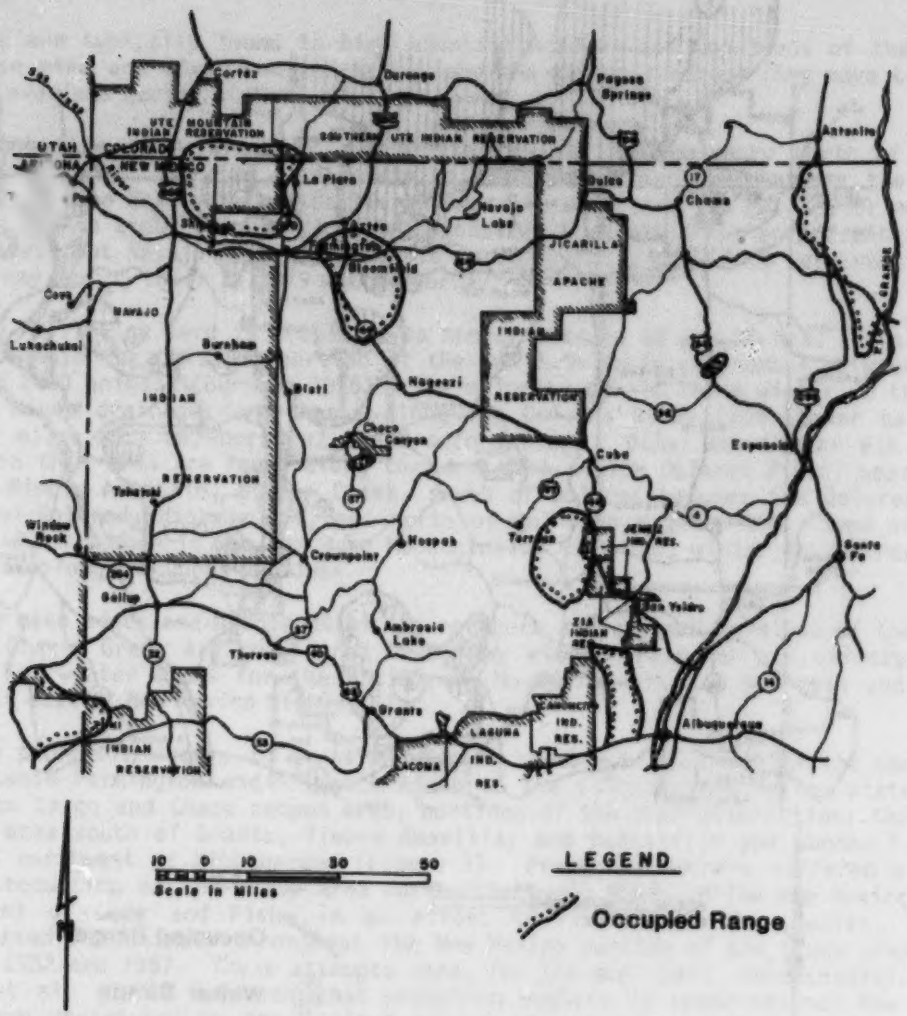

Figure 3. Pronghorn range, San Juan Basin Regional Uranium Study Area. (Sources: New Mexico Department of Game and Fish, Colorado Division of Wildlife, Navajo Fish and Wildlife).

sheep are usually found in alpine habitat or the upper edge of the mixed conifer forest. They inhabit rugged cliffs and crags or other extremely rocky terrain adjacent to suitable feeding areas (Findley et al. 1975). In all situations habitat is "open" in nature and relatively stable in character (Wilson 1979). Wilson also stated that water is an essential component of wild sheep habitat, with 7 miles (11.2 km) being postulated as the maximum distance between water sources that will permit some degree of uniform use to be made of their habitat.

The Barbary sheep, an exotic from North Africa, has been introduced into Largo Canyon, the Laguna Indian Reservation, and the Mt. Taylor area (Kinsky 1977, F. Winter[5] 1979, personal communication). Limited hunting (25 permits in 1978) is permitted in the Largo Canyon area. Seventy-five Barbarys were taken on the Laguna Reservation during their 1978 hunt. The diet of Barbary sheep parallels that of deer (Ogren 1965) and it is possible that Barbary sheep compete with deer for food, especially during winter. Barbary sheep prefer pinyon-juniper habitat.

There is an unverified rumor that tahr, a goatlike animal, have escaped from a game farm near Bibo, New Mexico, and are now established in that area. Three species of tahr exist: the Himalayan, Nilgiri, and Arabian, in their native South and Central Asia (Schaller 1977), but it is not known which species may be present in New Mexico. Schaller states that the Himalayan tahr is now established in Ontario and California.

Tahr are extremely adaptable, occupying diverse habitat in Asia (Schaller 1977). However, they appear to prefer steep slopes and cliffs broken by ledges and platforms. The steep-sided mesas and canyons of the Bibo area appear to be good habitat for these animals.

PERISSODACTYLA

The feral horse, although not considered to be "wildlife" by many people, is mentioned because of the possible impacts incurred by this species on the environment. Many management problems have been attributed to the presence of feral horses, including competition with wildlife and livestock for forage and water, overgrazing, trampling of forage, and destruction of range improvements (McKnight 1964). Feral horses are quite adaptable and will utilize any habitat where their preferred foods are found (Storrar et al. 1977). Feral horse populations can be found on the Navajo and Jicarilla Apache Indian Reservations and in the Jicarilla District of the Carson National Forest. Nelson (1978) conducted a behavioral study of feral horses on the latter area.

[5]U.S.D.A. Forest Service, Cibola National Forest, Albuquerque

BIRDS

The study area is thought to support 311 species of birds representing 17 taxonomic orders. Birds of the area are discussed by order and species. Preferred habitat, season of use, and special requirements of the different species are also discussed. Bird-habitat associations are listed in Appendix Table A2.

Of all the bird species utilizing the area, 198 species are in some way dependent upon riparian habitat. Ninety-three species are directly dependent on it for survival and reproduction.

The grassland-desert shrub community supports 96 bird species of which 23 are restricted to this habitat type and are dependent on it for survival and reproduction.

The pinyon-juniper type supports 135 species. Eight species are completely dependent upon this type. The ponderosa pine type hosts 105 species and 7 species are restricted to this type for survival and reproduction.

Mixed conifer forests support 71 species of birds on the study area; one avian species is dependent upon this vegetative type for its survival.

The alpine tundra habitat supports at least 13 species of birds on the study area and one species is totally dependent upon this vegetative type.

GAVIIFORMES

The common loon migrates and winters on the area and is found mainly on larger bodies of water (Hubbard 1978).

PODICIPEDIFORMES

Grebes of the study area are represented by four species. Kinsky (1977) reported that the eared grebe and the pied-billed grebe are known to breed in marshy areas of the San Juan Basin. He reported that the other species, the western grebe and the horned grebe are rare winter visitors to the area and are found on bodies of open water of all sizes.

PELECANIFORMES

Two species of the order Pelecaniformes inhabit the study area. The white pelican, according to Hubbard (1978), is most common in New Mexico in the San Juan and Canadian valleys. This bird is piscivorous and has been observed in flocks of up to 30 or more at Red Lake near Window Rock (J. Antonio[6] 1978, personal communication). The white pelican is listed by the State of Colorado as threatened. The double-crested cormorant is also a fish-eater. Both birds are migrants on the study area (Hubbard 1978) and are usually found on large open bodies of water.

[6]Navajo Fish and Wildlife, Window Rock, Arizona.

CICONIIFORMES

Most birds of this order are found in riparian habitat. The great blue heron feeds on aquatic animals and usually nests in cottonwoods along streams or adjacent to large reservoirs (Bailey and Niedrach 1965). These birds are residents of the area (Hubbard 1978).

The green heron, another riparian dweller, is a summer resident of the San Juan Valley (Hubbard 1978).

The great egret is reported as casual in the summer at Farmington (Hubbard 1978). The cattle egret has recently been sighted in the study area near upper Nutria Village, Zuni Reservation, New Mexico (J. Jojola[7] 1978, personal communication). The snowy egret is listed by most researchers as being on the study area, but few observations have been verified. One such verification was made at Nutria Reservoir No. 2 on the Zuni Reservation (T. Merkel[8] 1979, personal communication). The black-crowned night heron summers on the Jicarilla Reservation (Hubbard 1978) and has been seen elsehwere on the study area.

The least bittern and the American bittern can be found in the study area. The least bittern is casual at Kirtland, New Mexico (Schmitt 1973). The American bittern nests in marshy areas at Blanco and Kirtland (Schmitt 1973).

ANSERIFORMES

Twenty-five species of waterfowl occur on the study area. Water sources utilized by these birds range from small stock tanks to large reservoirs. The whistling swan migrates and winters in the area and is usually found on large bodies of water at lower elevations (Hubbard 1978).

The Canada goose migrates and winters in the area (Hubbard 1978). The white-fronted goose and the snow goose are spring and fall migrants. Geese can be found in grain fields and aquatic areas throughout the study region.

The ducks of the study area, represented by 21 species, are grouped into four subfamilies. There are nine species of surface-feeding ducks (Anatinae) on the area. These ducks feed mainly by tipping, rather than diving for their food; therefore, they thrive in areas of shallow water where they can reach vegetation or other foods. Ducks included in this subfamily are the mallard, gadwall, pintail, green-winged teal, blue-winged teal, cinnamon teal, American wigeon, northern shoveler, and the wood duck (Hubbard 1978).

Bay ducks (Aythyinae) eat more animal matter than surface feeding ducks and dive under the water's surface to obtain their food. They are not restricted to areas with shallow water as are surface feeding ducks. Bay ducks on the area include the redhead, ring-necked duck, canvasback, lesser scaup, common goldeneye, Barrow goldeneye, bufflehead, and the surf scoter (Hubbard 1978). These ducks migrate and winter on the study area and are less

[7]U.S. Fish and Wildlife Service, Gallup, New Mexico.

[8]U.S. Fish and Wildlife Service, Gallup, New Mexico.

common or absent during the summer months (Hubbard 1978). The less common surf scoter and Barrow goldeneye have been verified near Farmington (Hubbard 1978).

The ruddy duck is the only member of the subfamily Oxyurinae, the stiff-tailed ducks, to occur within the study area. Ruddy ducks usually feed in water from 2-10 ft (0.6-3 m) deep, and occasionally on the water's surface (Bellrose 1976). Their chief food is vegetation. Ruddy ducks can be found year round on the study area (Hubbard 1978).

FALCONIFORMES

The study area supports 18 species of this order. These birds are diurnal flesh-eaters. Most take live prey, but some are scavengers (Robbins et al. 1966). Several studies have been conducted on the predator-prey relationships of this order (Craighead and Craighead 1956, Luttich et al. 1970, Hornocker et al. 1976).

The turkey vulture, a scavenger, is common and is reported to nest at high elevations on the study area (Bailey and Niedrach 1965). It is considered rare in dense riparian habitat near Kirtland, New Mexico (Schmitt 1973).

The Mississippi kite is on New Mexico's (Group II) and Arizona's (Group IV) endangered lists. Hubbard (1978) reports this species to be rare to uncommon in summer. They are usually found in riparian woodland at lower elevations (Hubbard 1978). Sightings on the area include the San Juan Valley, near Kirtland (Schmitt 1973).

The goshawk is a resident of the study area (Hubbard 1978). These raptors are found in pinyon-juniper, ponderosa pine, and mixed conifer habitats (Bailey 1932, Kinsky 1977) and are known to nest in the San Juan and Jemez mountains (Hubbard 1978).

The marsh hawk, a harrier, feeds on small mammals, small birds, game birds, and insects (Bent 1937). These birds can be found within the study area at any season but are resident only locally (Hubbard 1978). They inhabit riparian and grassland-desert shrub environments (Kinsky 1977). Breeding records include the San Juan Valley near Kirtland, New Mexico (Schmitt 1973).

The osprey is a fish-eater inhabiting areas near rivers and lakes on the study area. It is presently listed on the New Mexico (Group II) and Arizona (Group III) endangered species list. Riparian habitat is preferred by this species (see endangered species section).

The prairie falcon, a resident, nests on cliffs located near its preferred habitat --grassland-desert shrub (Hubbard 1978).

The peregrine falcon (U.S.D.I. Fish and Wildlife Service 1979) is a summer resident of the study area (Hubbard 1978). These birds nest on cliffs located in grassland-desert shrub areas (see endangered species section).

The merlin migrates and winters over most of the study area (Hubbard 1978). It is found in pinyon-juniper and ponderosa environments and is more numerous and widespread in some years than others.

The American kestrel, a resident of the area, ranges from grassland-desert shrub areas to the alpine zone (Bailey and Niedrach 1965, Hubbard 1978).

GALLIFORMES

Members of the order Galliformes are chicken-like birds. They are capable runners that forage on the ground for seeds and insects (Robbins et al. 1966). Since they are usually nonmigratory, they are classified as residents where found. The sage grouse is found in the grassland-desert shrub and is closely associated with sagebrush (Wallestad 1975). Sage grouse historically occurred in New Mexico but there is no current evidence that they now exist here (Hubbard 1978). This species is on Group I of the New Mexico endangered list (see endangered species section). These birds are considered uncommon in the Dove Creek and Great Cut areas of the Colorado portion of the study area (U.S.D.I. Bureau of Reclamation 1978).

The blue grouse occurs in ponderosa pine and mixed conifer habitat (Weber 1975, Hubbard 1978, U.S.D.I. Bureau of Reclamation 1978), and is common at higher altitudes in Colorado. Phillips et al. (1964) reported blue grouse in the Chuska Mountains of Arizona and Hubbard (1978) records them from the Chuskas, San Juan, Jemez, Zuni, and Mt. Taylor areas of New Mexico.

Sharp-tailed grouse are found near Mancos, Colorado (U.S.D.I. Bureau of Reclamation 1978). They inhabit shrubby areas of the pinyon-juniper, ponderosa pine and mixed conifer habitats.

The white-tailed ptarmigan may occur on the Colorado portion of the study area. This bird is found on high mountain peaks above timberline and feeds on dwarf willow and subalpine fir needles (Robbins et al. 1966, Johnsgard 1973).

There are two species of quail in the region. The scaled quail is the most common, ranging from resident to local (Hubbard 1978). The distribution of the scaled quail conforms to the grassland-desert shrub type (Campbell et al. 1973, Johnsgard 1975). The Gambel quail is less common in the area as a result of introductions (Hubbard 1978). Gambel quail also inhabit grassland-desert shrub areas (Johnsgard 1975).

The ring-necked pheasant, a native of Asia, has been introduced into the region. It occupies farm land nearly all of which is irrigated (Campbell 1976).

The chukar, also a native of Asia, was introduced into the San Juan Valley and is now considered a resident (Bohl 1957, Campbell 1976, Hubbard 1978). Bailey and Niedrach (1965) reported that, in the Colorado portion of the study area, these birds prefer broken rimrock land and a dry climate.

The wild turkey is an important game species. It is found in montane regions of the area and prefers mixed conifer, ponderosa pine, and riparian habitats (Edminster 1954, Spicer 1959, MacDonald and Jantzen 1967).

GRUIFORMES

The order Gruiformes is a diverse group of wading birds with long legs. Other features such as size, body shape, feeding habits, and neck length are variable. Most birds of this order are found in agricultural areas or riparian habitat.

The whooping crane and sandhill crane are possible wanderers into the area during migration. The whooping crane is an endangered species (U.S.D.I. Fish and Wildlife Service 1979). Its possible occurrence is a result of the "Foster Parent Program", administered by the U.S. Fish and Wildlife Service and the Canadian Wildlife Service, which involves transplanting whooping crane eggs into the nests of sandhill cranes. Hatched young are raised by the sandhill cranes. The sandhill crane population involved in this program concentrates during spring and fall in the San Luis Valley, Colorado, which is only a short distance northeast of the study area (Sanderson 1977). Cranes feed on wild and cultivated grains and small aquatic animals.

The Virginia rail is reported by Hubbard (1978) as breeding near Farmington and at least occasionally on the Jicarilla Reservation. It feeds on invertebrates and seeds of marsh plants (Martin et al. 1951). These birds are found in marshy habitat. The sora's range and food habits are similar to the Virginia rail (Hubbard 1978). The common gallinule is reported as casual and breeding in the San Juan Valley near Kirtland, New Mexico (Schmitt 1973). Johnsgard (1975) reports this riparian dweller to breed near still or slow-moving waters. The American coot is a resident on most of the study area (Hubbard 1978). The ecology of the coot is considered by Johnsgard (1975) to be more similar to diving ducks than that of typical rails. Both waterfowl eat submerged and shoreline vegetation and invertebrates.

CHARADRIIFORMES

This order is represented by the avocets, stilts, plovers, sandpipers, phalaropes, snipes, gulls, and terns. Although 37 species are reported for the area, 28 are generally rare and occur only casually as migrants (Kinsky 1977, Hubbard 1978).

The American avocet is known to breed on the Jicarilla Reservation, preferring to nest on ponds found in grassland-desert shrub, pinyon-juniper, riparian, or ponderosa pine areas (Hubbard 1978).

The mountain plover also breeds on the area, occurring in grassland-desert shrub and riparian habitats (Kinsky 1977, Hubbard 1978). Hubbard (1978) claims that in the last decade the semipalmated plover, a riparian habitat dweller, has become regular in the San Juan Valley.

The most common sandpiper, the killdeer, is a resident and occurs in riparian, grassland-desert shrub, and pinyon-juniper habitats (Hubbard 1978). Killdeer usually breed in open habitats near water and locally in dry areas.

The common snipe, a game bird, migrates and winters throughout New Mexico and summers in the Chama Valley (Hubbard 1978). Fogarty et al. (1977) show the breeding range of the common snipe extending into the study area in

southern Colorado. These birds are also riparian habitat dwellers (Kinsky 1977).

Gulls are usually found in riparian habitat. The herring gull and ring-billed gull are found during migration and in winter months (Hubbard 1978). Subadults of the ring-billed gull are also found during summer in the San Juan Valley and on the Jicarilla Reservation (Hubbard 1978). The Bonaparte gull is a casual visitor to the San Juan Valley during summer (Hubbard 1978). Other gulls occur only during migration.

The only tern reported as a resident is the black tern (Hubbard 1978). During the summer it is found in the San Juan Valley and on the Jicarilla Reservation. Other terns are migrants. Terns usually inhabit riparian areas.

COLUMBIFORMES

Pigeons and doves are small-headed, short-legged, swift flying birds which feed on grains, small seeds, acorns, and fruits (Robbins et al. 1966).

The band-tailed pigeon is an important game species. These birds occur in highest densities at elevations of 5500-8500 ft (1677-2593 m) and prefer the ponderosa pine habitat or areas with Gambel oak (Braun et al. 1975).

The rock dove has been introduced from Europe. It is found almost exclusively in association with human habitation and is considered an undesirable inhabitant of farm and city dwellings (Kinsky 1977).

The mourning dove provides the largest annual harvest of any game bird in New Mexico (Sands 1972) and in the United States (Peters 1961). This bird can be found in any habitat type. Ligon (1961) reported them to occur from the lowest elevation in New Mexico to its highest peaks. Grain-producing agricultural areas are among the mourning dove's favorite feeding grounds. Hubbard (1978) reports nesting sites vary from grassland-desert shrub to ponderosa pine communities. These birds are permanent residents of the study area, but they become less common during winter (Hubbard 1978).

The Inca dove is casual to occasional in the San Juan Valley (Hubbard 1978). This bird is usually associated with residential areas (Phillips et al. 1964).

CUCULIFORMES

The yellow-billed cuckoo summers and migrates on the study area (Hubbard 1978). These birds feed mainly on hairy insects (Robbins et al. 1966). They nest in lowland riparian habitat such as the San Juan Valley (Schmitt 1973).

The roadrunner is a yearlong resident (Bailey and Niedrach 1965). Hubbard (1978) cites these birds as casual to occasional at Farmington, Chaco Canyon, and Grants. Roadrunners prefer grassland-desert shrub and riparian habitats (Kinsky 1977, Hubbard 1978). They are found locally in pinyon-juniper habitat (Hubbard 1978).

STRIGIFORMES

Most owls are nocturnal birds of prey. All fly silently hunting for rodents and other small animals (Robbins et al. 1966).

The barn owl is an infrequent summer resident in Colorado (Tyler and Phillips 1978). In New Mexico, they are reported to be resident almost statewide with breeding records for Sandoval County (Hubbard 1978). Barn owls roost and nest in barns, when available, but often must use cavities in cliffsides or potholes in arroyos (Tyler and Phillips 1978). These owls occur in grassland-desert shrub and riparian habitats (Kinsky 1977).

The screech owl can be found in any habitat which contains holes in trees (Tyler and Phillips 1978). They occur from the pinyon-juniper up through mixed conifer habitats (Tyler and Phillips 1978) and in low to middle elevation riparian habitats (Hubbard 1978).

The flammulated owl is known to summer in New Mexico almost statewide, with breeding records for the Zuni Mountains (Hubbard 1978). This species inhabits the pinyon-juniper, ponderosa pine, and mixed conifer zones (Hubbard 1978, Tyler and Phillips 1978).

The great horned owl is a resident over most of the study area (Bailey and Niedrach 1965, Hubbard 1978). Habitats in which these birds are found include riparian, pinyon-juniper, ponderosa pine, and mixed conifer (Bailey and Niedrach 1965, Hubbard 1978, Tyler and Phillips 1978).

Pygmy owls are known to reside in the Chuska Mountains and Navajo Lake areas (Hubbard 1978). These birds prefer pinyon-juniper and ponderosa pine communities (Bailey and Niedrach 1965).

The burrowing owl is a summer resident that nests in burrows made by other animals (Tyler and Phillips 1978). In many areas it is closely associated with the prairie dog (Bailey and Niedrach 1965, Tyler and Phillips 1978). Preferred habitat of this owl includes grassland-desert shrub and pinyon-juniper types (Zarn 1974, Hubbard 1978).

The spotted owl is a resident of mountainous regions of the study area (Hubbard 1978). Its' habitats include canyons in forests, pine-oak woodlands, mixed conifer, and adjacent riparian areas (Hubbard 1970, Zarn 1974a, Tyler and Phillips 1978).

Long-eared owls are irregular in the summer throughout New Mexico with breeding records near Farmington and Grants (Hubbard 1978). These owls range from grassland-desert shrub up through the mixed conifer areas (Tyler and Phillips 1978).

The short-eared owl occurs during winter and migration within the study area (Kinsky 1977). These birds are found in the grassland-desert shrub vegetation type and are fond of marshy areas (Ligon 1961, Hubbard 1978, Tyler and Phillips 1978).

The saw-whet owl, a summer resident, is an inhabitant of riparian, ponderosa pine, and mixed conifer areas (Hubbard 1978, Tyler and Phillips 1978). Hubbard (1978) noted this species as breeding in the Zuni Mountains.

CAPRIMULGIFORMES

This order is comprised of nocturnal insect eaters (Robbins et al. 1966), two species of which occur in the study area. These are the poorwill and the common nighthawk. Both of these birds are summer residents and migrants on the study area (Hubbard 1978). They inhabit riparian, grassland-desert shrub, pinyon-juniper, and ponderosa pine vegetation types (Hubbard 1978).

APODIFORMES

This order includes the swifts and hummingbirds. Swifts that are present on the study area include the black swift and white-throated swift. Both are summer residents and migrants in all six major habitat types discussed in this report (Hubbard 1978).

Hummingbirds found in the grassland-desert shrub habitat are the broad-tailed and rufous (Pearson 1936, Ligon 1961, Lowe 1964, Phillips et al. 1964, Hubbard 1978). These authors report the black-chinned, broad-tailed, rufous, and Rivoli from riparian areas, and associated the black-chinned, broad-tailed, and rufous hummingbirds with pinyon-juniper. The calliope and all previously mentioned hummingbirds were said to occur in the ponderosa pine community. The black-chinned and calliope were further associated with residential areas.

CORACIIFORMES

This piscivorous order is only represented by the belted kingfisher. These birds are reported to occur on the study area during summer, in migration, and less frequently during winter (Bailey and Niedrach 1965, Hubbard 1978). They require riparian habitat and are found near bodies of water which contain fish populations.

PICIFORMES

Ten species of woodpeckers occur on the study area. The common flicker is said to be the most common woodpecker in New Mexico (Ligon 1961). It can be found in any habitat which contains trees (Bailey and Niedrach 1965, Hubbard 1978). This includes riparian, pinyon-juniper, ponderosa pine, and mixed conifer habitats (Bailey and Niedrach 1965, Kinsky 1977, Hubbard 1978).

Ladder-backed woodpeckers are usually resident up to 6300 ft (1920 m) in the more arid parts of New Mexico (Ligon 1961). This species was sighted at Mt. Taylor in 1972 (Hubbard 1978). Hubbard (1978) reports inhabitants from grassland-desert shrub and locally up into mixed conifer habitats.

The red-headed woodpecker is on the New Mexico endangered species list (Group II) (see endangered species section). In New Mexico this species is strictly associated with lower elevation riparian woodlands and planted groves of trees (Hubbard et al. 1978). Schmitt (1973) reported evidence of breeding in the San Juan Valley.

Two sapsuckers, the yellow-bellied and Williamson, can be found in similar habitats on the study area. Both breed in the woodlands of the Chuska, San Juan, Jemez, Mt. Taylor, and Zuni ranges (Hubbard 1978), and are found in pinyon-juniper, ponderosa pine, and aspen communities (Kinsky 1977, Hubbard 1978).

The hairy and downy woodpeckers are resident in the mountainous parts of the study area (Bent 1939, Hubbard 1978). Both are found from riparian lowlands up to the ponderosa pine habitat with the hairy woodpecker extending into the mixed conifer zone (Phillips et al. 1964, Kinsky 1977). The less common downy woodpecker breeds in the San Juan Valley (Hubbard 1978).

The northern three-toed woodpecker is a resident of ponderosa pine and mixed conifer habitats (Ligon 1961, Hubbard 1978). Hubbard (1978) cites breeding records for the Chuska, Jemez, and Zuni mountains and resident or summer records for Mt. Taylor and the San Juan Mountains.

PASSERIFORMES

This order is very diverse; therfore, these birds will be discussed at the family level.

The flycatchers (family Tyrannidae) are named for their feeding habit of catching insects on the wing. Most of the flycatchers are summer visitors (Hubbard 1978); the say phoebe is the only flycatcher that is a year-round resident (Hubbard 1978). This phoebe is a permanent resident of the grassland-desert shrub community and a summer visitor to mountainous areas (Hubbard 1978). The buff-breasted flycatcher, listed on the New Mexico and Arizona endangered lists, was a resident of Valencia County before 1973 (Hubbard et al. 1978). It is not known if they still occur. Favored habitats of this species are ponderosa pine and pinyon-juniper (Hubbard et al. 1978) (see endangered species section).

The larks (family Alaudidae) are only represented by the horned lark. These larks are residents of the desert lands but they also breed in alpine meadows (Hayward et al. 1976).

The swallow family (Hirundinidae) includes six summer visitors to the area. They are almost exclusively insectivorous and occupy habitats from grasslands to pine forests (Kinsky 1977). They are more commonly found near water where insects are more abundant (Kinsky 1977).

Nine species of the jay and crow family (Corvidae) are found on the study area, with eight being residents; the nonresident is the blue jay (Hubbard 1978). The blue jay is irregular in pinyon-juniper and riparian habitats of the area (Hubbard 1978) but has been recorded as breeding in the San Juan Valley (Gennaro 1973).

Resident Corvids are found mostly in mountain environments. Included are the gray jay, found in mixed conifer habitat; the Steller's jay, which occurs in mixed conifer, ponderosa pine, and pinyon-juniper woodlands; the pinyon jay found in pinyon-juniper woodlands; the Clark's nutcracker found in mixed conifer, ponderosa pine, and pinyon-juniper habitats; and the scrub jay, inhabiting pinyon-juniper areas (Kinsky 1977, Hubbard 1978).

Some members of this family are also found at the lower elevations. The black-billed magpie, common raven, and common crow can be found in all habitats from grassland-desert shrub through mixed conifer (Kinsky 1977, Hubbard 1978).

The families Paridae, Sittidae, and Certhiidae are sometimes combined because chickadees, bushtits, titmice, nuthatches, and creepers are all small woodland and forest birds (Kinsky 1977). All of these birds present are residents, occurring from lowland riparian areas (Kinsky 1977) up to the mixed conifer habitat (Blackford 1956).

The dipper is the only representative of the family Cinclidae present. This small, short-winged bird is restricted to clear mountain streams in ponderosa pine, mixed conifer, and alpine habitats (Ligon 1961).

Wrens (family Troglodytidae) are represented by six species. The presence of the winter wren has not been verified on the area, but it may occur in mixed conifer communities (Blackford 1956, Hubbard 1978). Other wrens are reported by Kinsky (1977) to breed on the study area. Kinsky (1977) stated that the rock wren and canyon wren can be found on cliffs, rocky slopes, and in canyons. The long-billed marsh wren is restricted to riparian habitat (Hubbard 1978), while the Bewick's wren and house wren are found in thicket-type areas of riparian and pinyon-juniper habitats (Kinsky 1977). The house wren is also found in ponderosa pine habitats (Kinsky 1977).

The northern mockingbird, gray catbird, and thrashers (family Mimidae) are primarily grassland and shrubland type birds (Kinsky 1977). Northern mockingbirds and sage thrashers are year-round residents in grassland-desert shrub habitats (Kinsky 1977). The gray catbird is known to breed on the Jicarilla Reservation (Hubbard 1978). Kinsky (1977) reported that the Bendire thrasher is a summer resident and breeds from desert shrubland to pinyon-juniper woodland areas. The brown thrasher is rare to uncommon throughout the area (Hubbard 1978).

The family Turdidae is represented by five species. The eastern bluebird is a rare visitor, occurring in lowland riparian habitat (Kinsky 1977, Hubbard 1978). The western bluebird and mountain bluebird are residents of mountainous areas from pinyon-juniper type to mixed conifer communities (Hubbard 1978). Hubbard also noted local populations of western bluebirds in lowland habitat. The hermit thrush, Swainson's thrush, and Townsend's solitaire are summer visitors to the mountain environments (Hubbard 1968).

The blue-gray gnatcatcher, golden-crowned kinglet, and ruby-crowned kinglet are very small insectivorous birds belonging to the family Sylviidae. The kinglets are found in mountainous areas, preferring mixed conifer habitat, and the blue-gray gnatcatcher prefers riparian, grassland-desert shrub or pinyon-juniper areas (Blackford 1956, Hubbard 1978).

Pipits (family Motacillidae) are represented by a single species, the water pipit. This species is found from riparian lowlands during migration up into the alpine tundra during breeding season (Hubbard 1978).

Birds of the family Bombycillidae include the Bohemian waxwing and the cedar waxwing. Both species are winter residents in the area and are found

from grassland-desert shrub to pinyon-juniper habitats (Hubbard 1978). These birds are often found in residential areas which contain berry producing shrubs.

The shrikes (family Laniidae) are hawklike songbirds with food preferences for lizards, small birds, and insects (Kinsky 1977). In productive areas, the loggerhead shrike is a common year-round resident of grassland-desert shrub habitats. The northern shrike is a casual visitor in wooded areas during winter months (Kinsky 1977, Hubbard 1978).

The starling, family Sturnidae, is a native of Europe which was introduced to New York City in 1890 (Ligon 1961). They now occur in very high densities in agricultural and residential areas, and many believe the species is taking over breeding habitats of native birds (Kinsky 1977).

Vireos (family Vireonidae) are rather small, greenish or olive-sided birds of woodland and forest (Ligon 1961). Five species of vireos occur within the study area. The Hutton, gray, solitary, and warbling vireos are summer residents of mountains and riparian areas. These birds are found in wooded areas with the Hutton and gray vireos preferring habitats with oak, and the warbling vireo preferring habitats with aspen (Hubbard 1978). The red-eyed vireo is a rare migrant to pinyon-juniper areas and was recorded in Farmington in 1977 (Kinsky 1977, Hubbard 1978).

Twenty-eight species of warblers (family Parulidae) can be found on the study area. Seven of these species are known to breed there (Kinsky 1977, Hubbard 1978).

The yellow warbler, MacGillivray warbler, and common yellowthroat are primarily riparian breeders (Griscom and Sprunt 1957, Kinsky 1977, Hubbard 1978). The yellow-rumped warbler, Grace warbler and black-throated gray warbler are woodland and forest breeders (Griscom and Sprunt 1957, Kinsky 1977). The remaining warblers are uncommon, found in summer or during migration.

The family Plocediae is represented by the house sparrow. This very competitive European native was introduced to the United States at Brooklyn, New York in 1851 and 1852 (Ligon 1961). It is now abundant about villages, cites, and rural settlements throughout the Southwest (Ligon 1961). These birds are considered pests and will take over birdhouses and feeders meant for other species.

There are 11 members of the family Icteridae (blackbirds and allies) reported for the area. Most are primarily riparian breeders (Kinsky 1977). The red-winged blackbird, yellow-headed blackbird, and brown-headed cowbird are the most numerous on the area (Kinsky 1977). Several species, including the Scott oriole, Brewer blackbird, and western meadowlark, breed in grassland-desert shrub areas (Kinsky 1977). The red-winged blackbird is the only year-round resident (Hubbard 1978).

The tanagers (family Thraupidae) are represented by three summer visitors (Hubbard 1978). The western tanager and hepatic tanager are found in pinyon-juniper, ponderosa pine, mixed conifer, and riparian communities, while the scarlet tanager is located in riparian and pinyon-juniper habitats

(Hubbard 1978). The western tanager is the only tanager known to breed on the area (Hubbard 1978).

The family Fringillidae is a large and diverse group of seed eaters which is represented on the study area by 28 species. Birds of this family are found in all habitats producing seeds and the species perform similar ecological tasks. These birds include the grosbeaks, towhees, juncos, sparrows, and longspurs. Most members are migrants throughout the area during summer or winter months; a few are year-round residents (Kinsky 1977, Hubbard 1978). Breeding grosbeaks include the black-headed grosbeak, blue grosbeak, indigo bunting, and Lazuli bunting (Kinsky 1977). The black-headed grosbeak breeds in pinyon-juniper and ponderosa pine forests and the aforementioned latter three breed in riparian areas of the grassland-desert shrub habitat (Kinsky 1977). Kinsky (1977) reported the other grosbeaks as casual migrants.

Finches breeding in the area are the house finch, pine siskin, American goldfinch, lesser goldfinch, and the red crossbill (Bailey and Niedrach 1965, Kinsky 1977, Hubbard 1978). Each of these species occupies a wide range of habitats, generally breeding at higher elevations and moving into lower elevations during the winter months (Bailey and Niedrach 1965, Hubbard 1978). Other finches are visitors to the area.

The brown towhee and rufous-sided towhee are found from lowland riparian habitat up to ponderosa pine habitat with the rufous-sided towhee extending into mixed conifer habitat (Hubbard 1978). The green-tailed towhee is only found during the summer with no breeding evidence apparent (Hubbard 1978).

Among the 24 sparrows present, most are migrants, summer visitors, or winter visitors. Breeding birds include only one resident, the gray-headed junco (Hubbard 1978). Other breeders are the sage sparrow, black-throated sparrow, Lincoln sparrow, and the song sparrow (Hubbard 1978, Kinsky 1977). The Baird sparrow is listed by New Mexico as an endangered species (Group II) (see endangered species section). It has been verified in Rio Arriba County and the San Juan Mountains (Hubbard et al. 1978). This species is found in grassland and agricultural areas (Hubbard et al. 1978).

REPTILES AND AMPHIBIANS

Reptiles and amphibians are grouped together for study purposes purely for historical reasons (Cochran and Goin 1970). Amphibians are vertebrates that lack any covering of the skin. They have at least one pair of legs, though these are sometimes so small that they may escape notice unless looked for (Cochran and Goin 1970). Amphibians lay their shell-less eggs in water or in moist places on land.

Reptiles are vertebrate animals covered with scales, rather than with feathers or hair as birds and mammals are (Cochran and Goin 1970). They may or may not have legs. Reptiles lay shelled eggs on land or else are ovoviviparous (Cochran and Goin 1970).

There are 14 species of amphibians and 34 species of reptiles known to exist on the San Juan Regional Uranium Study area (Appendix Table A3). These animals have been grouped by order and are discussed at the species level. Their preferred habitats and special requirements needed for survival are presented.

Few herpetological studies have been done on the study area. Therefore, abundance and distribution of some species are not completely understood.

Some of the information in this section of the report was obtained from the U.S.D.A. Forest Service by use of their "Run Wild" computer printout. For further information on this program see Patton (1978).

CAUDATA

There are two species of salamanders found on the study area. The tiger salamander occurs in a variety of habitats. This species thrives in quiet waters of ponds, reservoirs, lakes, temporary rain-pools and streams (Stebbins 1966). It ranges from the grassland-desert shrub up through mixed conifer habitats. These animals are used as fish bait, thus they have been spread to many environments by fishermen and are considered common in the study area.

The Jemez Mountains salamander is much more restricted in its habitat preferences. This species is endemic to the Jemez Mountains of the Santa Fe National Forest (U.S.D.A. Forest Service 1975) and is on New Mexico's endangered list (Group II) (Hubbard et al. 1978). This species is restricted to such a small area that it was not discovered until 1949 (Stebbins and Riemer 1950). They are completely terrestrial and are found in mossy talus areas of the mixed conifer habitat (Williams 1972a, Hubbard et al. 1978). The U.S. Forest Service (1975) reported that the presence of volcanic talus, which provides crevices for easy vertical movement in response to fluctuating environmental conditions, appears to be essential to this species.

ANURA

Four toads are present on the study area. The boreal toad is a common western toad, but it is listed as endangered (Group II) in New Mexico where

its range reaches its southeastern limit (Campbell and Degenhardt 1971, Hubbard et al. 1978). This toad is found from grassland-desert shrub habitat up to the mixed conifer communities frequenting desert streams and springs, grasslands, woodlands, and mountain meadows (Stebbins 1966). They have been known to occur at elevations up to 10,000 ft (3,048 m) in Colorado (Stebbins 1966).

The Great Plains toad and red-spotted toad are found in grassland-desert shrub habitat and the riparian communities of this type (Stebbins 1966). The Great Plains toad prefers grasslands, mesquite woodlands, and sagebrush plains. The red-spotted toad is fond of desert oasis, open grassland, rocky canyons, and arroyos (Stebbins 1966, Cochran and Goin 1970). Stebbins (1966) stated that the red-spotted toad, although sometimes seen on the floodplains of rivers, is more often associated with rocky sites. The red-spotted toad has been recorded in the southern part of the study area and Chaco Wash, New Mexico (Kinsky 1977).

Woodhouse's toad is found from grassland-desert shrub to mixed conifer habitats (Stebbins 1962). Heymann (1975) reported this species favors semi-arid deserts or canyon woodland near marshy streams. Woodhouse's toad was found to be widespread throughout the San Juan Basin (Harris 1963).

Canyon tree frogs found on the study area occur in arroyos in the grassland-desert shrub habitat and near streams in ponderosa pine habitat (Stebbins 1966). This species is considered rare on the study area (J. Applegarth[9] 1979, personal communication).

The Arizona tree frog is found at higher elevations. It frequents meadows of the ponderosa pine and mixed conifer habitats (Stebbins 1966). This species is possibly found in the extreme southwestern boundary of the study area. Stebbins (1966) cites an old record for McKinley County, New Mexico.

Western chorus frogs are found in portions of the study area which receive heavy snowfall (J. Applegarth 1979, personal communication). This species breeds in spring, utilizing pools formed from melting snow.

The bullfrog, a game species in New Mexico, has been introduced to the San Juan River drainage. This species rapidly displaces native species of frogs (J. Applegarth 1979, personal communication) and is known to prey on young waterfowl. Bullfrogs are highly aquatic and are totally dependent on a permanent water supply. They prefer quiet water which supports a thick growth of cattails or other aquatic vegetation (Stebbins 1966).

Northern leopard frogs are found from grassland-desert shrub habitat up into alpine habitat near sources of permanent or semi-permanent water (Lowe 1964, Stebbins 1966). They favor areas with cattails and "plenty" of insects (Bernard and Brown 1972).

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The spadefoot toads are found in grassland-desert shrub habitat (Stebbins 1966). These toads avoid permanent water. They congregate and breed during spring and summer rains (Heymann 1975). Eggs hatch within 2 days and tadpoles transform into toads in approximately 2 weeks. Species found are the Couch's spadefoot, plains spadefoot, and western spadefoot.

CHELONIA

The painted turtle is found in the San Juan River and its tributaries (Degenhardt and Christiansen 1974). These turtles prefer slow moving, shallow water found in ponds, marshes, lakes, and creeks (Ernst and Barbour 1972). A soft bottom, clear water, basking sites, and aquatic vegetation are required for survival of this species (Ernst and Barbour 1972, J. Applegarth 1979, personal communication).

The western box turtle is found in northwestern New Mexico in places frequented by tourists (Degenhardt and Christiansen 1974). Degenhardt and Christiansen did not include these northwestern localities on their range maps of New Mexico because of the likelihood that the specimens were released outside the natural range of the species.

SQUAMATA

There are 15 species of lizards living within the study area. The lesser earless lizard is found in grassland-desert shrub habitat. It prefers exposed patches of sand or gravel (Stebbins 1966).

Chihuahua whiptails range from grassland-desert shrub into oak-pine and ponderosa pine forests where they prefer rocky hillsides, sandy alluvium of washes, and canyons (Stebbins 1966). All Chihauhua whiptails are females, therefore, they must reproduce by parthenogenesis (Smith 1974).

The plateau whiptail is found on the study area inhabiting open, sparsely vegetated areas. They occur from grassland-desert shrub to ponderosa pine habitats and are occasionally found in riparian areas (Stebbins 1966). This species is also parthenogenic.

Western whiptails range from grassland-desert shrub to ponderosa pine habitats (Stebbins 1966). This species prefers areas of sparse vegetation but is also found in woodland streamside growth, and warmer, drier parts of the forest.

The little striped whiptail is a desert-grassland species, but ranges into the grassy areas of the pinyon-juniper woodland (Applegarth 1973). It is mostly limited to sandy or silty alluvial fans and slopes.

Collared lizards are found in riparian, grassland-desert shrub, and pinyon-juniper habitats. Boulders for basking and lookouts, and open areas for running appear to be essential for this species (Stebbins 1966). Kinsky (1977) reports this species to be abundant and widespread on the study area.

The leopard lizard is restricted to grassland-desert shrub habitat (Stebbins 1966). This species may be found on any soil type but avoids dense grass and brush which interferes with running (Stebbins 1966). Taylor (1965) reported this species to have a highly disjunct distribution in northwestern New Mexico.

Skinks of this area are found from grassland-desert shrub to ponderosa pine and riparian habitats (Stebbins 1966). They favor moist sites. The Great Plains skink is found only in the Zuni Mountains and Mt. Taylor area and favors rocky sites (Kinsky 1977). The many-lined skink is primarily found in areas of heavy deciduous growth (Gehlback 1965).

Short-horned lizards occur in a variety of habitats. They are more cold-adapted than other horned lizards and range from riparian situations at lower elevations up through pinyon-juniper and oak-pine to mixed conifer associations (Applegarth 1973). This species should be moderately common on the study area, where loose soil is present (Stebbins 1966, Applegarth 1973).

The sagebrush lizard is found from grassland-desert shrub up to mixed conifer habitats (Stebbins 1966). Requirements seem to be good illumination, open ground, and scattered low bushes (Stebbins 1966). This species is common and widespread in shrubby locations of the area (Harris 1963, Jones 1970).

The desert spiny lizard is found in lower elevations of the northwestern portion of the study area. It prefers desert brushland, pinyon-juniper woodlands, and river courses grown to willow and cottonwoods (Stebbins 1966).

Eastern fence lizards are abundant throughout the study area and are found in a variety of habitats (Stebbins 1966, Applegarth 1973, Kinsky 1977). Stebbins (1966) reports them from mixed conifer down to grassland-desert shrub seeking shelter in bushes, trees, old buildings, wood piles, rodent burrows, and under rocks, logs, or other objects.

Rock lizards are found from grassland-desert shrub to ponderosa pine habitats. Applegarth (1973) reported this species to be fairly common in McKinley County, New Mexico and most often found on or near large rock outcrops and loose boulders in the cholla-juniper and pinyon-juniper communities.

The side-blotched lizard is found in grassland-desert shrub and pinyon-juniper habitats associated with rocks along washes (Stebbins 1966, Applegarth 1973). Applegarth (1973) reported this species common in the San Juan Basin.

Snakes of the study area are represented by 17 species. The glossy snake is found in grassland-desert shrub and pinyon-juniper habitats (Lowe 1964, Stebbins 1966). It generally prefers open sandy areas and is seldom encountered due to its nocturnal habits (Applegarth 1973).

The coachwhip snake is found in the southeast portion of the study area (Stebbins 1966). This species occurs in grassland-desert shrub and pinyon-juniper habitats where they prefer rocky or sandy soil.

Striped whipsnakes inhabit grassland-desert shrub, pinyon-juniper, and ponderosa pine habitats and are often attracted to rocky stream courses, both permanent and intermittent (Ortenburger 1928, Stebbins 1966).

Three species of rattlesnakes are found on the study area. The western diamondback rattlesnake is found in the southeastern portion of the study area, ranging from riparian lowlands through grassland-desert shrub, pinyon-juniper, and ponderosa pine habitats (Stebbins 1966). This is the largest western rattlesnake and possibly the most dangerous. It is capable of injecting more venom in a single bite than any other species found in the western United States (Minton and Minton 1969).

Blacktail rattlesnakes are found in riparian, grassland-desert shrub, pinyon-juniper, and ponderosa pine habitats (Stebbins 1966). This species avoids barren desert. Over much of its range it is a mountain snake inhabiting rockslides, outcrops, and rocky stream courses (Stebbins 1966). This species is only known from the Mt. Taylor section of the area.

The prairie rattlesnake is found from grassland-desert shrub habitat up through mixed conifer habitat (Stebbins 1966). This species frequents rock outcrops, talus, rocky stream courses, and rock ledges and is found throughout the study area.

The ring-necked snake is found in moist habitats. This species is restricted to ponderosa pine and mixed conifer habitats, or riparian areas at lower elevations (Stebbins 1966).

Bullsnakes are found on the study area in a variety of habitats ranging from grassland-desert shrub to mixed conifer vegetation types (Stebbins 1966). Soils utilized by this snake include sand, loam, rock, or hardpan. This species is common on the study area (J. Applegarth 1979, personal communication).

The night snake occurs on rock and sandy areas in grassland-desert shrub and pinyon-juniper habitats (Stebbins 1966). This is a rear-fanged snake, and subdues its prey by injecting venom through enlarged, grooved teeth toward the back of the upper jaw (Stebbins 1966).

The common kingsnake is found in the vicinity of rock outcrops and clumps of vegetation or under rotting logs, old lumber, and rocks. These environments are found on the study area in riparian, ponderosa pine, and mixed conifer habitats.

Milk snakes are found from grassland-desert shrub through mixed conifer environments. This snake is usually located inside rotten logs and stumps and under rocks, logs, bark, and boards (Stebbins 1966).

The smooth greensnake is found in damp, grassy environments (Stebbins 1966) that occur on the study area in riparian and mixed conifer habitats.

Longnose snakes are desert snakes in this part of the Nation (Stebbins 1966). They prefer agricultural areas or shrubby environments.

The mountain patchnose snake might be found on the study area. Gehlbach (1965) reports this species in pinyon-juniper habitat at the southeast corner of the Zuni Mountains. Mountain patchnose snakes seem to favor rock hillsides and canyons in the lower part of the pinyon-juniper zone (Applegarth 1973).

The plains blackheaded snake is a resident in grassland-desert shrub and pinyon-juniper habitats. These snakes are found in the southeast portion of the study area (Stebbins 1966). They are usually located under rocks, boards, and other objects by day and occasionally in the open at night (Stebbins 1966). This species is protected by law in Colorado (Bernard and Brown 1977), but does not occur on the Colorado portion of the study area.

Black-necked garter snakes are found from grassland-desert shrub to ponderosa pine habitats. Applegarth (1973) believes this snake to be most common in pinyon-juniper woodlands. This species frequents permanent and intermittent streams, but in wet weather may wander far from water (Stebbins 1966, Bernard and Brown 1977).

The wandering garter snake occurs in a great variety of habitats. It ranges from the grassland-desert shrub up into the mixed conifer habitats (Stebbins 1966). These snakes are primarily terrestrial, but are well adapted to water, being found near permanent or intermittent streams and ponds (Bernard and Brown 1977). Stebbins (1966) reports these snakes to be most common on moist soils.

FISHES

Fifty species of fish occur within the study area (Appendix Table A4); 16 are endemic to the region. The following discussion relates each species to its habitat requirements. Much of the information presented is general, but specific data are provided in some instances. When possible, various habitat parameters such as water velocity, water depth, substrate, water temperature, and dissolved oxygen content are discussed. The selection of specific habitat parameters may be influenced by age, seasonal, and diurnal factors. The fishes are grouped and discussed by order and family. Appendix Table A5 provdes a summary of the fishes and the bodies of water in which they are found on the study area.

SALMONIFORMES

Family Salmonidae: This family is represented by six species within the study area: the cutthroat trout, rainbow trout, brown trout, brook trout, coho salmon, and kokanee. Bovee (1978) summarized the habitat requirements (velocity, depth, substrate, and temperature) of these species and other salmonids by means of probability-of-use curves. Table 2 shows the optimum habitat requirements (probability-of-use = 1.0) for these species.

Water temperature is the most important environmental parameter determining the suitability of a body of water for trout (Tebo 1974). Temperature affects all metabolic and reproductive activities of fishes including growth, swimming, and the ability to capture and assimulate food. Optimum temperature requirements may vary with life stage and season. Cutthroat trout prefer and function best at lower temperatures than do the introduced brook, brown, and rainbow trouts (Behnke and Zarn 1976). Native cutthroat trout coexist with and dominate introduced species only in cold headwater situations. No native cutthroats remain within the New Mexico portion of the study area, although some may be present in the upper tributaries of the San Juan in Colorado (G. Thorne[10] 1979, personal communication).

Adequate dissolved oxygen is necessary for survival and reproduction of trout and the instream organisms upon which they depend for food (Tebo 1974). Trout require high levels of dissolved oxygen, 5.0-7.0 ppm being optimum.

Substrate characteristics are important in determining the composition and productivity of benthic macroinvertebrates (Smith and Moyle 1944, Tebo 1974). Rubble is most productive, with decreases in productivity occurring as particle size decreases. Spawning usually occurs in gravel or cobble riffles. Brook trout will spawn in sand or gravel, but apparently require upwelling ground water (White and Brynildson 1967). Brown trout choose riffles without upwelling. Stuart (1953) showed that the hydraulic characteristics of the streambed at the crests of riffles, where brown trout most often spawn, promotes downward flow of the water through the gravel, thereby circulating oxygen to the eggs.

[10]New Mexico Dept. Game and Fish, Albuquerque.

Table 2. Optimum habitat requirements of salmon and trout (Bovee 1978).

Species	Velocity (ft/sec)	Depth (ft)	Temperature (°F)	Substrate
Coho salmon				
Spawning	1.2-1.4	0.5-0.8	41-48	100% gravel
Fry	0.5-0.6	1.6-2.0	53-59	100% gravel
Kokanee				
Spawning	0.6-0.8	0.4	48-52	100% gravel
Cutthroat trout				
Spawning	0.8-1.0	0.7-0.8	49-51	100% gravel
Adult	1.2-1.7	1.5-1.8	52-66	80% gravel + 20% sand to 80% boulder + 20% cobble
Juvenile	0.6-1.2	1.4-1.6	54-66	100% gravel
Fry	0.4-0.6	0.6-0.9	54-66	100% gravel to 80% gravel + 20% cobble
Rainbow trout				
Spawning	1.4-1.9	0.7-0.8	52-56	100% gravel
Adult	1.2-1.4	1.7-4.0	54-68	60% gravel + 40% cobble to 60% cobble + 40% boulder
Juvenile	0.7-1.4	0.8-1.1	54-68	100% gravel
Fry	0.4-0.6	0.6-0.9	54-68	100% gravel
Brown trout				
Spawning	1.5-2.0	0.6-0.8	45-46	100% gravel
Adult	0.0-0.9	2.5-4.0	54-68	90% sand + 10% gravel to 60% cobble + 40% gravel
Juvenile	0.0-0.5	0.7-2.8	54-68	80% cobble + 20% gravel to 90% cobble + 10% boulder
Fry	0.0-1.2	0.8-1.8	54-67	80% sand + 20% gravel to 80% gravel + 20% cobble
Brook trout				
Spawning	0.6-1.1	0.5-0.6	43-45	50% sand + 50% gravel
Adult	0.0-0.5	0.8-2.0	58-60	80% cobble + 20% gravel

For other references on trout habitat see Greene (1950), Doudoroff (1957), Bachman (1958), Coble (1961), Baldes and Vincent (1969), Burns (1970), Hartman and Galbraith (1970), Hooper (1973), and Reiser and Wesche (1977).

Kokanee, the lacustrine version of the sockeye salmon, have been stocked in several lakes on the study area (Appendix Table A5). Kokanee prefer water temperatures close to 50°F (10°C) (Seeley and McCammon 1966). Kokanee must have a cool, well-oxygenated layer of water available during the summer months.

Coho salmon have been stocked in Navajo Dam, El Vado and Abiquiu reservoirs, Rio Chama, and Bluewater Lake. Table 2 lists habitat requirements for this species. These fish do best in cool water lakes (McAfee 1966). Natural reproduction in the Colorado River system seems unlikely due to lack of suitable habitat (Minckley 1973).

Family Esocidae: The northern pike is the only member of this family found within the study area. It has been introduced into several lakes within the region (Appendix Table A5).

The northern pike is found in a variety of habitats. Diana et al. (1977) found that pike selected vegetated zones when possible. Pike were seldom found in water over 13.1 ft (4 m) deep, and usually were within 984 ft (300 m) of shore. During winter when submergent vegetation dies and emergent vegetation is reduced by ice cover, pike were not found within 328 ft (100 m) of shore as often as in summer. Also, depths utilized at this time were somewhat greater than during summer.

Spawning occurs in spring when water temperatures are 40-52°F (4-11°C) (Scott and Crossman 1973). Spawning substrate is submerged vegetation. Pike do not spawn in cattails, extensive areas of pond lilies, coontail, milfoil, bladderwort, or water shield (Franklin and Smith 1963). Pike can survive in alkaline lakes with total alkalinities as high as 1000 ppm and a pH of 9.5 (Scott and Crossman 1973). High alkalinities can reduce or prevent spawning.

CYPRINIFORMES

Family Cyprinidae: Sixteen cyprinids can be found within the study area. The carp, a native of Asia, occurs in the San Juan River, Morgan Lake, Navajo Dam, Navajo Wash, Jackson Lake, Dolores River, Rio Chama, Abiquiu Dam, Heron Reservoir, and El Vado Reservoir (Appendix Table A5). In New Mexico, carp are found in waters ranging from 2800 ft (853 m) to 7500 ft (2286 m) in elevation (Jester 1974). Carp prefer shallow to moderately shallow water that is stagnant or slow moving, with a loamy, muddy bottom and abundant aquatic vegetation. Carp in Utah prefer water depths of 3-4 ft (0.9-1.2 m) if adequate cover is available (Sigler 1958). Occasionally they are taken at depths of 100 ft (30.5 m) (Pflieger 1975). Average optimum water temperature is about 68°F (20°C).

Spawning occurs in spring when water temperature is about 60°F (16°C), and is most active at 65-68°F (18-20°C) (Sigler 1958). The upper lethal temperature for carp is 96°F (36°C), while they are inactive below 38°F (3°C) Black 1953, Sigler 1958). Carp can tolerate very low oxygen levels and extreme variations in temperature and pollution (Lagler and Latta 1954).

The longfin dace is a native of the Gila drainage that has been introduced into the Zuni River (Koster 1957). This is the most successful, highly adaptable, cyprinid fish native to the American southwest deserts (Minckley 1973). Habitat ranges from low, hot sandy-bottomed desert streams to the cool brooks in the lower conifer zones. Sand is the usual spawning substrate (Koster 1957). Merkel[11] (1979, personal communication), believes this fish is no longer present in the Zuni drainage.

The goldfish is native to eastern Asia, but has been introduced widely throughout the United States and Canada (Scott and Crossman 1973). The goldfish seems to be most successful in small bodies of water, such as ponds. It is often taken in streams below hatcheries and in large impoundments where it is commonly used as bait (Pflieger 1975). The goldfish has been reported from the La Plata drainage in Colorado (Colorado Division of Wildlife 1975).

The lake chub has also been cited as occurring in the La Plata drainage (Colorado Division of Wildlife 1975). This species is native to Canada and the northern United States (Scott and Crossman 1973). Lake chub are quite adaptable in their habitat requirements, but prefer lakes or large rivers.

The Rio Grande chub typically inhabits small, cool streams with moderate to swift currents (Miller 1952). It is a midwater swimmer in terms of water depth. They are usually found in pools, but spawn in riffles (Koster 1957).

Habitat of the bonytail chub is reported to be the turbid, heavily silted waters of the Colorado River system, especially those associated with swift water canyon areas (Joseph et al. 1977). Vanicek and Kramer (1969) also said this chub occurred in pools and eddies away from strong currents in silt bottom areas. This species has not been confirmed in New Mexico (Hubbard et al. 1978). Further research by Hubbard has revealed that this species has never occurred in New Mexico. It is on the New Mexico endangered list (Group I).

The roundtail chub is found in all habitats, from riffles to stagnant backwaters (Holden and Stalnaker 1975). They are most commonly found in deeper pools of large streams (Hubbard et al. 1978). Cross (1978) collected roundtail chubs and 62% were in runs, 35% in pools, and 3% in riffles. Seventy percent occurred over sand and silt substrates, while 30% were collected over gravel or rubble. Average depth of water was 1.1 ft (0.33 m). Current velocities ranged from 0.0-3.6 ft (1.1 m) per second ($\bar{x}$ = 1.1 ft or 0.33 m per second). This species is also on the New Mexico endangered list (Group II).

The brassy minnow is found in the Dolores River system in the northwestern part of the study area. Pflieger (1975) states that the brassy minnow inhabits small, clear streams having permanent pools and sandy or gravel bottoms.

The flathead chub is native to rivers and creeks east of the Continental Divide (Koster 1957). They are usually found in streams with strong currents and a shifting bottom.

[11] T. Merkel, U.S. Fish and Wildlife Service, Gallup, New Mexico

Golden shiners have been stocked in Bluewater Lake (Parish 1977). This fish is normally an inhabitant of lakes and quiet streams (McKechnie 1966), but does well in stagnant waters and can tolerate extremely low oxygen levels. The golden shiner is a valuable forage fish and is used extensively by largemouth bass and crappie (McKechnie 1966). This shiner has not been found in Bluewater Lake since it was rotenoned in 1977.

The red shiner is native to rivers, creeks, and canals at lower elevations east of the Continental Divide (Koster 1957). This species is now present in the Colorado River system (Hubbs 1954), and occurs in the San Juan drainage, being found in a variety of habitats including pools, backwaters, and riffles (Pflieger 1975). It is tolerant of high turbidity and siltation. The red shiner is vary adaptable in its spawning requirements (Pflieger 1975). Eggs may be deposited in green sunfish nests, but it commonly spawns on clean, gravel riffles or submerged debris such as logs. They also spawn on submerged vegetation.

The fathead minnow inhabits silty lakes and streams (Miller 1952). Koster (1957) states that in streams the fathead minnow is usually found in "pools over muddy bottom" where little or no current exists. Vegetation and debris such as boards, rocks, and logs are used as spawning substrate (Pflieger 1975). This fish is quite tolerant of high temperatures, turbidity, and low oxygen.

The Colorado squawfish is an endangered species (U.S.D.I. Fish and Wildlife Service 1979) that occurs in the San Juan River. In April 1978 one was captured near Aneth, Utah just below the junction of McElmo Creek (Seethaler 1978). This is the first record of a squawfish from the San Juan proper since 1965.

The Colorado squawfish occurs in a variety of habitats. In fact, some investigators have found it in such diverse situations that they believe the squawfish does not show distinct habitat preferences (Vanicek and Kramer 1969). Seethaler (1978), however, reviewed all known Colorado squawfish literature and concluded that definite habitat preferences are shown by this fish. He found young-of-the-year to prefer quiet backwaters with little or no current (0.49 ft or 0.15 m/sec), a firm silt bottom, and a depth of 0.98-1.96 ft (0.3-0.6 m). Juveniles were found in shallow pools near shore with little or no current, but in deeper water (0.98-5.91 ft or 0.3-1.8 m) than young-of-the-year. Substrate is usually silt or sand. Subadult and adult squawfish occupy eddies, runs, and backwaters, usually with a sand substrate. Velocity varies from 0 to 3.0 ft (0.9 m) per second. Depth ranges from 0.98-9.84 ft (0.3-3 m).

The longnose dace is native to watersheds east of the Continental Divide (Koster 1957). Its usual habitat is rocky riffles in cool streams, although it does live in lakes and rivers. This fish is found close to the bottom, under and among stones in water with moderate current. Spawning substrate is gravel (Koster 1957). The speckled dace is the most widespread freshwater fish in the western United States (Williams 1978). It is common in main rivers, streams, and canals west of the Continental Divide (Koster 1957).

While speckled dace are usually considered riffle fish, they are found in all habitats (Holden and Stalnaker 1975, Joseph et al. 1977). John (1964)

reports speckled dace from intermittent streams in Arizona (Minckley 1973). Speckled dace usually live in water 1.6 ft (0.5 m) deep.

The redside shiner, a native to the Pacific Northwest, has been reported from the La Plata drainage (Colorado Division of Wildlife 1975). This minnow occurs in moderately fast streams, small ponds, and large lakes with widely varying temperatures and trophic conditions (Scott and Crossman 1973).

Family Catostomidae: The longnose sucker, a native of the northern States and Canada, has been reported from the La Plata drainage (Colorado Division of Wildlife 1975). It is considered to be the most successful and widespread cypriniform of the north (Scott and Crossman 1973), and in its native habitat occurs "almost everywhere in clear, cold water in moderately large numbers".

The white sucker inhabits both streams and lakes. In New Mexico it is native to the Arkansas and upper Pecos drainages, and has been introduced elsewhere (Koster 1957). It prefers streams with gravel or rock bottoms and well defined riffles (Pfleiger 1975). Spawning substrate is usually gravel. The white sucker, when abundant, provides excessive competition for trout (Koster 1957), and native mountain suckers diminish or disappear when the white sucker is introduced.

The bluehead sucker is highly restricted to areas of rock or gravel substrate, although it has been found in areas of sand substrate in late winter (Joseph et al. 1977). Young are found in slower water such as backwaters and eddies. This species is uniquely adapted for scraping periphyton from rocks and apparently feeds in this manner.

The Rio Grande sucker is found in fast, rocky riffles and rocky pools (Koster 1957). It is most abundant in flowing water downstream from swift riffles.

The ecology of the Zuni Mountain sucker is similar to the bluehead and Rio Grande suckers (U.S.D.I. Fish and Wildlife Service 1978). Within the study area the Zuni Mountain sucker is found only in the Zuni River drainage (Hubbard et al. 1978). They occur in a variety of habitats, ranging from montane streams (upper Rio Nutria) to a silt-laden stream with a low streambed gradient (lower Rio Pescado) and a freshwater marsh (Nutria Springs) (U.S.D.I. Fish and Wildlife Service 1978b). Water temperature varies from 39°F (3°C) to 78°F (25°C). This fish is on the New Mexico endangered list (Group II).

The flannelmouth sucker is found in all habitat types (Holden and Stalnaker 1975), but prefers pools and eddies of the main channels of larger streams (Joseph et al. 1977). They do not often inhabit backwaters as adults, but young are usually abundant in backwaters associated with main channels.

The humpback sucker appears to prefer backwaters of rivers or impounded waters (Holden and Stalnaker 1975). It generally inhabits water more than 3.3 ft (1 m) deep, often to depths greater than 49 ft (15 m) over sand, mud or gravel substrates (Minckley 1973). This fish is considered to be threatened and the process for listing as a threatened species has been initiated by the U.S. Fish and Wildlife (U.S.D.I. Fish and Wildlife Service 1978a). The humpback sucker has never been collected in the San Juan drainage of New Mexico, but has been caught near Mexican Hat, Utah.

SILURIFORMES

Family Ictaluridae: In their native environment, channel catfish inhabit moderate to swiftly flowing streams (Miller 1966a). They prefer sand, gravel, or rubble bottoms which may or may not be mixed with mud. They seldom live in dense aquatic vegetation. Channel catfish prefer warm water and do not grow well at temperatures less than 70°F (21°C). Lethal dissolved oxygen levels for channel catfish which were gradually acclimated were 0.76, 0.89, and 0.92 ppm at 77, 86, and 95°F (25, 30, and 35°C), respectively (Moss and Scott 1961).

The black bullhead prefers warmwater ponds, sloughs, and sluggish creeks and rivers (Miller 1966b). Mud is the usual bottom substrate (Koster 1957). At 71-73°F (22-23°C) lethal oxygen concentration is 3-3.4 ppm (Moore 1942). This species is highly tolerant of industrial and domestic pollutants and warm water (Trautman 1957).

Brown bullheads are most abundant in warmwater lakes, ponds, and sluggish streams, where it prefers quiet, clear waters with moderate or large amounts of submerged aquatic vegetation (Pflieger 1975). Brown bullheads have survived temperatures as high as 97°F (36°C) (Fry 1947) and can tolerate relatively high CO_2 levels and low O_2 levels (Black et al. 1954).

Habitat requirements of the yellow bullhead are much like those of the brown bullhead, but it is found less frequently in flowing waters (Pflieger 1975).

ATHERNIFORMES

Family Cyprinodontidae: Two members of this family are found within the study area: the plains killifish and the Rio Grande killifish. Both species are characteristic of shallow, sandy-bottomed streams (Minckley 1973). Both species have been introduced from outside the study area (Koster 1957). The plains killifish buries in sandy substrates as an escape technique (Minckley and Klassen 1969). Reproduction occurs over sand or small-rubble bottoms in water less than 3.9 in (10 cm) deep.

Family Poecilidae: The mosquitofish is a very adaptable fish and succeeds in almost all suitable habitats (Minckley 1973). In general this species avoids current, being found in shallows, often in dense vegetation (Koster 1957).

PERCIFORMES

Family Centrarchidae: The green sunfish is adapted for stream life (McKechnie and Tharratt 1966). They prefer warm, shallow areas of streams and weedbeds in lakes and reservoirs. It can be found in many border-line trout waters, but can survive temperatures of 92-94°F (33-34°C) for days (Sigler and Miller 1963). Carlander (1977) states that in California, green sunfish are especially abundant in streams with warm, turbid, muddy bottomed pools and large amounts of vegetation. The green sunfish will tolerate total alkalinities up to 2000 ppm (Carlander 1977).

The pumpkinseed, introduced to the La Plata drainage, inhabits clear, quiet waters with much aquatic vegetation (Pflieger 1975). Black (1953) determined the upper lethal temperatures for pumpkinseeds, acclimated at 64.4°F and 75.2°F (18°C and 24°C), to be 82.4°F and 86.4°F (28.0°C and 30.2°C).

The orange-spotted sunfish is commonly found in streams with low or intermittent flow in its native habitat, and is tolerant of siltation and continuous high turbidity (Pflieger 1975). It avoids streams with high gradient, clear or cool water, and continuous strong flow. The orange-spotted sunfish has been introduced to the La Plata drainage where it is considered uncommon (Colorado Division of Wildlife 1975).

The bluegill, also a warmwater fish, prefers protected areas with clear, quiet water, scattered vegetation, and a bottom substrate of sand, gravel, or much (Emig 1966b). Water temperatures of 60-80°F (16-27°C) are best for growth (Rounsefell and Everhart 1953). Bluegills have been reported to survive temperatures of 95°F (35°C) (Snow et al. 1960). Spawning occurs in spring when water temperature approaches 67°F (19°C). Spawning substrate is usually sand or gravel. Under laboratory conditions, bluegills tend to avoid water with dissolved oxygen concentrations of 1.5 ppm or less (Whitmore et al. 1960). Bluegills have survived in waters with pH's ranging from 4.0-10.4 (Trama 1954). They do not do well in waters with more than 900 ppm total alkalinities (Carlander 1977).

The smallmouth bass occurs naturally in large, clear-water lakes and cool, clear streams having moderate current and a substrate of rock and gravel (Coble 1975). The only places smallmouth bass are found within the study area are Navajo Dam and the upper San Juan (Appendix Table A5). Smallmouth bass prefer water temperatures of 79-82°F (26-28°C) (Coble 1975). The fish becomes torpid when temperatures drop below 40°F (4°C), while upper lethal temperature is about 95°F (35°C). Smallmouth bass usually inhabit water less than 40 ft (12 m) deep in lakes. In streams, this fish is found in the lee of objects near the edge of the current (Coble 1975).

The largemouth bass is the principal warmwater predatory fish in the United States (Heidinger 1975). It is often found in deep, open water, but most of its activities are associated with shorelines. Winter (1977) found largemouth bass in water between shore and 9.8 ft (3 m) deep. Largemouth bass prefer nonflowing waters such as lakes and ponds which contain aquatic vegetation and clear water (Emig 1966a). A temperature of about 80°F (27°C) is most suitable. This species is inactive below 50°F (10°C) (Simon 1951). Spawning begins in spring when water temperatures reach 60-75°F (15-24°C). Oxygen requirements are similar to the bluegill (Whitmore et al. 1960).

Preferred bottom types of the largemouth bass are mud with organic debris, gravel, sand, or hard nonflocculent clays (Trautman 1957). Sand, gravel, or aquatic vegetation is required for successful spawning (Emig 1966a). They will not spawn on silt bottoms (Robinson 1961). Also, waters with a salinity over 5000 ppm, or a pH below 5.0 or above 10.0 are unsuitable for spawning (Swingle 1956).

White crappies seem to flourish under conditions of relatively high turbidities (Hall et al. 1954). Reproduction is in spring or early summer,

with spawning usually occurring near submerged brush or rock. Koster (1957) states that crappies spawn over gravel in water 3-8 ft (0.9-2.4 m) deep.

The black crappie is less tolerant of turbid conditions than the white crappie (Hall et al. 1954). Clear lakes and turbid lakes with mixed populations have black crappie predominating in clear waters and white crappie in turbid water.

Family Percidae: The Iowa darter and johnny darter, both introduced, are reported to occur in the La Plata and Animas drainages, respectively (Colorado Division of Wildlife 1975, Smith 1976). Populations of these fish are probably very small. Only one individual of each species has ever been caught.

The yellow perch is an introduced species, being native to the northern part of North America east of the Rockies (Minkley 1973). It does best in quiet waters of clear, weedy lakes and ponds (Koster 1957). Spawning substrate is sand, gravel, or vegetation (Pflieger 1975).

Family Cottidae: The mottled sculpin is widely distributed in the upper Colorado River basin, including the San Juan drainage (Joseph et al. 1977). This species' optimum habitat is clear, flowing streams with rocky substrate. Their unusual morphology and adaptations for life in this substrate makes the sculpin relatively secure against displacement by non-native suckers and minnows.

The Piute sculpin has been reported from the La Plata drainage (Colorado Division of Wildlife 1975). Although characterized as a stream fish of fast flowing water, nothing is known of its habitat characteristics in the upper Colorado River basin (Joseph et al. 1977).

INVERTEBRATES

This is a brief review of the invertebrates, both terrestrial and aquatic, that inhabit the study area. Invertebrates are of both ecological and economic importance. These animals serve as important food sources for many other forms of life. Some pollinate plants by means of their food-gathering activities. Many are important parasites or vectors of disease, or both, while other species can cause great economic losses to timber or agricultural resources. Still other invertebrates help in the decay and decomposition of dead organisms. Many are household pests.

Several studies have been conducted within the area of interest (Graves 1967, Sanchez 1975, Colorado Division of Wildlife et al. 1976, U.S.D.I. Bureau of Reclamation 1976, Sublette 1977), and these have supplied the data for this section. A complete list of terrestrial arthropods collected by U.S.D.I. Bureau of Reclamation (1976) is given in Table 3. Table 4 is a compilation of the aquatic invertebrates of the study area.

U.S.D.I. Bureau of Reclamation (1976) found the greatest abundance and diversity of terrestrial arthropods in riparian habitat. The grassland-desert shrub habitat supported the smallest amount of insects. Flies were the most abundant insects in this type. True bugs were the most numerous insects in the pinyon-juniper type; flies and damselflies were most numerous in the riparian and aquatic airborne habitats, respectively.

Studies of aquatic invertebrates by Graves (1967) and Sublette (1977) show similar results; mayflies, caddis flies, two-winged flies, and several species of snails were the most abundant aquatic organisms in the San Juan, Animas, and La Plata rivers. Sanchez (1975) found caddis fly and mayfly larvae to be the most numerous aquatic invertebrates in Whiskey Creek, which is located on the west side of the Chuska Mountains on the Navajo Reservation. Crayfish have been introduced to Bluewater Lake (Parish 1977) and a number of lakes on the Navajo and Zuni Indian Reservations, Activity and Acomita lakes at Fort Wingate Depot (T. Merkel 1979, personal communication).

Table 3. Terrestrial arthropods of San Juan County, New Mexico.

Order	Family
Odonta-dragonflies and damselflies	Coenagrionidae-narrow-winged damselflies
Orthoptera-grasshoppers	Acrididae-shorthorned grasshoppers Tettigoniidae-longhorned grasshoppers
Thysanoptera-thrips	Phlaeothripidae
Hemiptera-true bugs	Miridae-leaf bugs Phymatidae-ambush bugs Nabidae-damsel bugs Tingidae-lace bugs Lygaeidae-chinch bugs Coreidae-leaf-footed bugs Scutellaridae-shield-backed bugs Pentatomidae-stink bugs
Homoptera-cicadas, hoppers, aphids	Cicadidae-cicadas Membracidae-treehoppers Cicadellidae-leafhoppers Fulgoridae-planthoppers Delphacidae-planthoppers Dictyopharidae-planthoppers Cixiidae-planthoppers Psyllidae-jumping plant lice Aphididae-aphids
Coleoptera-beetles	Cicindelidae-tiger beetles Carabidae-ground beetles Malachiidae-soft-winged flower beetles Meloidae-blister beetles Mordellidae-tumbling flower beetles Tenebrionidae-darkling beetles Anobiidae-drugstore beetles Cerambycidae-longhorned beetles Chrysomelidae-leaf beetles Curculionidae-weevils
Neuroptera-lacewings	Chrysopidae-common lacewing
Lepidoptera-butterflies and moths	Pieridae-whiles and sulfurs Nymphalidae-brush-footed butterflies Sphingidae-sphinx or hawk moths Noctuidae-underwings, cutworms, dagger moths

Table 3. (Concluded)

Order	Family
Diptera-flies	Culicidae-mosquitos
	Chironomidae-midges
	Anisopodidae-wood gnats
	Stratiomyidae-soldier flies
	Tabanidae-horse and deerflies
	Acroceridae-small-headed flies
	Asilidae-robber flies
	Bombyliidae-bee flies
	Dolichopodidae-long-legged flies
	Syrphidae-flower flies
	Otitidae-picture-winged flies
	Tephritidae-fruit flies
	Sepsidae-black scavenger flies
	Drosophilidae-small fruit flies
	Chloropidae-fruit flies
	Trioxscelidae-trioxscelid flies
	Anthomyiidae-anthomyiid flies
	Muscidae-house flies
	Gasterophilidae-horse bot flies
	Calliphoridae-blow flies
	Tachinidae-tachinid flies
Hymenoptera-bees, wasps, ants	Braconidae-braconids
	Ichneumonidae-ichneumonids
	Chalcididae-chalcidids
	Cynipidae-gall wasps
	Chrysididae-cuckoo wasps
	Mutillidae-velvet ants
	Formicidae-ants
	Vespidae-paper wasps
	Colletidae-yellow-faced bees
	Andrenidae-mining bees
	Halictidae-mining bees
	Megachilidae-leafcutting bees
	Apidae-mining, digger, and honey bees
Araneida-spiders	Thomisidae-crab spiders
	Salticidae-jumping spiders
	Tetragnathidae-four-jawed spiders

Table 4. Aquatic invertebrates of the San Juan Basin Regional Uranium Study Area.[a]

Order	Family	Common name
Ephemeroptera	Ephemerellidae	Mayflies
	Baetidae	
	Heptageniidae[b]	
	Tricorythidae	
Odonata	Gomphidae	Dragonflies
	Aeshnidae	
	Coenagrionidae	
Plecoptera	Perlodidae	Stoneflies
	Pteronarcidae	
	Nemouridae	
	Chloroperlidae	
	Perlidae	
Trichoptera	Brachycentridae	Caddis flies
	Hydropsychidae	
	Limnephilidae	
	Hydroptilidae	
	Helicopsychidae	
	Rhyacophilidae	
	Leptoceridae	
	Lepidostomatidae[b]	
	Glossosomatidae	
Coleoptera	Elmidae	Aquatic beetles
	Dytiscidae	
	Psephenidae	
	Dryopidae	
	Hydrophilidae	
	Gyrinidae	
	Haliplidae[b]	
Diptera	Chironomidae	Two-winged flies
	Rhagionidae	
	Tipulidae	
	Blephariceridae	
	Simuliidae	
	Dolichopodidae	
	Ceratopogonidae	
	Culicidae	
	Deuterophlebiidae	
	Ephydridae	
	Syrphidae	
	Tanyderidae	
	Empididae	

Table 4. (Concluded)

Order	Family	Common name
Hemiptera	Corixidae	True aquatic bugs
	Naucoridae	
	Veliidae	
	Notonectidae	
	Gerridae	
Lepidoptera[b]	Pyralidae	Aquatic caterpillars
Thysanoptera		Thrips
Hydracarina		Water mites
Pulomonata	Lymnaeidae	Pond snails
	Physidae	Pouch snails
	Planorbidae	Orb snails
	Ancylidae	Limpets
Amphipoda	Talitridae	Scud or sideswimmers
Podocopa		Seed shrimps
Decapoda		Crayfish
Rhynchobdellida[b]	Glossiphoniidae	Leeches
Prosopora[b]	Lumbriculidae	Aquatic earthworms
Phylum Nematomorpha[b]		Horsehair worms
Phylum Nematoda		Roundworms
Phylum Platyhelminthes[b]		Flatworms

[a]References include Graves (1967), Sanchez (1975), Colorado Division of Wildlife et al. (1976), and Sublette (1977).

[b]Courtesy J. Anderson, Graduate Research Assistant, Dept. Fisheries and Wildlife Sciences, New Mexico State University, Las Cruces.

ENDANGERED SPECIES

The Endangered Species Act of 1973 (P.L. 93-205) recognizes that endangered species of wildlife and plants "are of esthetic, ecological, educational, historical, recreational and scientific value to the Nation and its people", and provides for the protection of not only true species, but subspecies and distinct populations thereof. The act establishes two groups of protected species: (a) "any species which is in danger of extinction throughout all or a significant portion of its range", i.e., endangered species, and (b) "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range", i.e., threatened species. The category of "threatened" is intended to function not only as a means of giving some protection to species before they become endangered, but also as a means of gradually reducing the level of protection for previously endangered species which have been successfully restored to the point at which the extreme protection for that category is no longer necessary (Bean 1977). Wildlife, as defined by the 1973 act, includes "any member of the animal kingdom."

State endangered species laws may differ somewhat from the Federal statute. For example, the New Mexico Wildlife Coordination Act of 1974 defines endangered species as those "whose prospects of survival or recruitment within the state are in jeopardy or are likely within the foreseeable future to become so." Thus, New Mexico's concept of endangerment is viewed with reference to populations within a geopolitical boundary rather than in the Federal sense of populations within a significant portion of or throughout a species range (Hubbard et al. 1978). Two categories are also used for listing under the New Mexico Wildlife Conservation Act. These are: (a) State endangered (Group I) -- species whose prospects of survival or recruitment within the State are in jeopardy, and (b) State endangered (Group II) -- species whose prospects of survival or recruitment within the State may become in jeopardy in the foreseeable future.

Arizona has defined four groups for its endangered wildlife (Arizona Game and Fish Commission 1978). Group I species are those known or suspected to be extinct in Arizona which still exist elsewhere in the United States or Mexico. Group II and Group III correspond closely to the Federal "endangered" and "threatened" categories, respectively. Group IV species are of interest primarily because of limited distribution. They are not species in a lesser degree of jeopardy than those in Group III.

Utah and Colorado provide endangered and threatened categories for their wildlife, very similar to the Federal groupings.

Twenty-four species of animals that are known or considered likely to be found within the study area are classified as endangered species (Table 5). Three species of plants have been proposed for listing (Table 5) and 10 plant species are considered extremely rare. The following is a brief review of the biology and ecology of these species.

Table 5. Endangered species of wildlife and plants found on the San Juan Basin Regional Uranium Study Area.

Common name	Scientific name	Status
Mammals		
Black-footed ferret	Mustela nigripes	Federal endangered, NM endangered (Group I), Colorado endangered, Arizona endangered (Group II), Utah endangered
Marten	Martes americana	NM endangered (Group II)
Mink	Mustela vison energumenos	NM endangered (Group II)
Spotted bat	Euderma maculata	Arizona endangered (Group III)
Birds		
Bald eagle	Haliaeetus leucocephalus	Federal endangered, NM endangered (Group I), Arizona endangered (Group II), Utah endangered
Peregrine falcon	Falco peregrinus anatum	Federal endangered, NM endangered (Group I), Colorado endangered, Arizona endangered (Group II), Utah endangered
Whooping crane	Grus americana	Federal endangered, NM endangered (Group I), Colorado endangered
Mississippi kite	Ictinia mississippiensis	NM endangered (Group II), Arizona endangered (Group IV)
Zone-tailed hawk	Buteo albonotatus	NM endangered (Group II), Arizona endangered (Group III)
Osprey	Pandion haliaetus carolinensis	NM endangered (Group II), Arizona endangered (Group III)
Sage grouse	Centrocercus urophasianus	NM endangered (Group I)
Red-headed woodpecker	Melanerpes erythrocephalus caurinus	NM endangered (Group II)
Buff-breasted flycatcher	Empidonax fulvifrons pygamaeus	NM endangered (Group I), Arizona endangered (Group IV)
Baird sparrow	Ammodramus bairdii	NM endangered (Group II)
White pelican	Pelecanus erythrorhynchos	Colorado threatened

Table 5. (Concluded)

Common name	Scientific name	Status
Amphibians		
Jemez mountains salamander	Plethodon neomexicanus	NM endangered (Group II)
Boreal toad	Bufo boreas boreas	NM endangered (Group II)
Fish		
Colorado squawfish	Ptychocheilus lucius	Federal endangered, NM endangered (Group I), Colorado endangered, Arizona endangered (Group II), Utah endangered
Humpback sucker	Xyrauchen texanus	Proposed Federal threatened, Colorado threatened, Arizona endangered (Group III), Utah threatened
Zuni mountain sucker	Catostomus (Pantosteus) discobolus yarrowi	NM endangered (Group II)
Bonytail chub	Gila elegans	NM endangered (Group I), Colorado endangered, Arizona endangered (Group II), Utah endangered
Roundtail chub	Gila robusta robusta	NM endangered (Group II)
Colorado river cutthroat trout	Salmo clarki pleuriticus	Colorado threatened
Invertebrates		
Blue-black silverspot butterfly	Speyeria nokomis nictocris	Propsed Federal threatened
Plants		
	Sclerocactus mesa-verde	Proposed Federal endangered
	Pediocactus knowltonii	Proposed Federal endangered
	Erigeron rhizomatus	Proposed Federal endangered

MAMMALS

Black-footed Ferret

The black-footed ferret is the only mammal classified as endangered, on both the Federal and various State lists, that might occur within the inventory area. The rarity, secretiveness, and nocturnal nature of this animal have made it extremely difficult to study, and very little is really known about it (Hubbard et al. 1978). Most observations of black-footed ferrets have been made in and around prairie dog towns, consequently it has been assumed that the ferret is almost totally dependent upon the prairie dog for food and its burrows for shelter. South Dakota studies have shown that black-footed ferrets give birth in May or June to four or five young (Hillman 1968, Fortenberry 1972, Henderson et al. 1974).

The black-footed ferret probably has never been a very common species, and it has undoubtedly suffered significant losses as a result of widespread prairie dog control programs (Hubbard et al. 1978). There have been no recent confirmed sightings of the ferret in the study area, although potential habitat exists on the Ute Mountain, Ute Reservation, the Navajo and Zuni Reservations, and Mt. Taylor area. The most recent reliable sightings have come from these areas. Brown and Howard (1978) and U.S.D.I. Bureau of Reclamation (1978) have found signs indicating the possible presence of ferrets in some of these areas.

Marten

The marten is on the New Mexico state endangered list (Group II). This animal preys on voles, red squirrels, pikas and snowshoe hares (Hubbard et al. 1978). They also feed on carrion, and during certain parts of the year berries make up a significant portion of their diet. Koehler et al. (1975) found red-backed and meadow voles, ground squirrels, insects and berries to be important in marten diets, with deer mice, shrews, chipmunks, snowshoe hares, flying squirrels, pikas and birds making up smaller amounts of their diet.

Koehler et al. (1975) and Koehler and Hornocker (1977) found greatest marten activity associated with mesic Engelmann spruce-subalpine fir communities over 100 years old with a canopy cover greater than 30%. Females begin breeding when 3 years of age and produce a litter of three to four young in the spring after a gestation period of 8-9 months (Hubbard et al. 1978). The long gestation period is due to delayed implantation.

Though widespread, marten populations have suffered declines in localized areas due to over-exploitation for furs and loss of habitat from logging operations. The species has already been eliminated from much of its former range (Koehler et al. 1975), and probably was never common on the study area. New Mexico is the southernmost distributional limit of the genus Martes in the United States (Hubbard et al. 1978). Within the study area this animal is known only from the San Juan Mountains.

Mink

The mink is also on the New Mexico endangered list (Group II). This animal is found in a variety of habitats, but seldom far from permanent water.

Small mammals, fish, birds, eggs, crayfish, and frogs make up a significant portion of its diet (Hubbard et al. 1978). The breeding season is from January to March. Four to 10 young are born after a gestation period of 1-3 months.

Although common throughout much of its range, the species has suffered a drastic decline in New Mexico. This decline is largely unexplained, but it is thought that such factors as habitat loss and trapping may have played a role in its demise (Hubbard et al. 1978). Historical records within the study area are from the San Juan and upper Rio Grande drainages.

Spotted Bat

The spotted bat is on the Arizona endangered list (Group III). There are no known population estimates for this species (Snow 1974). The population trend is probably static. Moths of the family Noctuidae appear to be the primary food item.

Little is known about reproduction in spotted bats. Lactating females have been captured in June, July, and August (Snow 1974). Easterla (1971) has recorded the only observation of a young bat. A captive female gave birth to a male which, 4 hours after birth, weighed 4g. The young bat nursed almost constantly for the first 48 hours.

It is believed that this bat has never been very common (Snow 1974) and that specific habitat requirements, such as the location of sedimentary cliffs in relation to water and food habits, may be limiting factors. The construction of dams which inundate high cliffs and canyon walls is possibly destroying spotted bat habitat.

BIRDS

Bald Eagle

The bald eagle is on the Federal list of endangered species. This bird spends much time in the vicinity of water, preying on feeding or scavenging fish, and to a lesser extent feeding on waterbirds and mammals (Hubbard et al. 1978). Nests are usually on trees, cliffs, or rock pinnacles near water. A breeding pair required 30-100 ac (12-45 ha) of undisturbed nesting territory (U.S.D.A. Forest Service 1975), with nesting sites within 0.5 mi (0.8 km) of permanent water which supports a fish population. The usual clutch size is two eggs. Eggs are unmarked, whitish, and average 2.75 x 2.08 inches (70 x 53 mm) (Reed 1965, Grubb and Rubink 1978).

Bald eagle populations have declined drastically in recent years, primarily because of ingestion of chlorinated hydrocarbon pesticide residues in prey (Hubbard et al. 1978). These residues interfere with the calcium metabolism of the bird, resulting in weak-shelled eggs which collapse under the weight of the incubating parent. Persecution (shooting, nest disturbance) has also been a problem.

Few nests have been found in the study area. Possible nesting activity has been reported from the Ute Mountain Ute Reservation of Colorado (U.S.D.I. Bureau of Reclamation 1978). The species seems to be widespread and locally

common during winter and migration, especially along major streams and reservoirs, i.e., San Juan River, Navajo Dam, El Vado Lake (Hubbard et al. 1978).

Peregrine Falcon

Also on the Federal list of endangered species, the peregrine falcon nests on cliffs that are high, near permanent water, and overlook large expanses of air in which these birds can forage (U.S.D.A. Forest Service 1975, Hubbard et al. 1978). Food items range from swallows to ducks, geese, and herons. Eyries are usually located on ledges or in potholes of cliffs. Breeding begins around April, and 3-4 white, reddish speckled eggs are laid on bare substrate. Average egg size is 2.05 x 1.5 inches (52 x 39 mm) (Reed 1965).

Populations of the peregrine have declined drastically since the 1940's primarily because of the uptake of the residues of chlorinated hydrocarbon pesticides which are ingested by many of its prey species (Snow 1972, Hubbard et al. 1978). Habitat destruction, shooting, and falconry have also contributed to the decline of this species. Within the study area, the peregrine has been sighted on the Zuni and Ute Mountain Ute reservations, and in the San Juan and Chaco Canyon regions.

Whooping Crane

The whooping crane, included on the Federal list of endangered species, is present in New Mexico and Colorado as a result of the Foster Parent Program mentioned earlier in this report. This bird attains sexual maturity when 3-4 years old (Hubbard et al. 1978). Adults pair for life and return to their old territories each year. Whoopers build their nests of grasses on the ground or mats of vegetation. Up to three eggs are laid, but usually only one chick survives to the fledgling stage. At the time of this writing, none of the whoopers raised in the Foster Parent Program, has reached breeding age. The whoopers winter on the Bosque del Apache National Wildlife Refuge south of Socorro, New Mexico and may pass through the eastern portion of the study area during their migration through the Rio Grande Valley.

Mississippi Kite

The Mississippi kite is on the New Mexico (Group II) and Arizona (Group IV) endangered lists. This is an extremely aerial species, spending most of its time, even when feeding, in flight (Hubbard et al. 1978). Their primary food is insects, particularly grasshoppers and cicadas. These birds build stick nests high in trees. Average clutch size is two to three eggs, with the whitish eggs averaging 1.65 x 1.26 inches (42 x 32 mm) (Reed 1965). Preferred habitat is lowland riparian woodland and planted groves (Hubbard et al. 1978). Vagrants of this species occur in the San Juan Valley. The New Mexico and Arizona populations represent the western limit of this raptor's range.

Zone-tailed Hawk

Also on Group II of the New Mexico endangered list and Group III of Arizona's list, this bird is an inhabitant of pinyon-juniper, riparian, and ponderosa pine communities (Hubbard et al. 1978). They prey on a variety of animals. Usually two to four whitish eggs are laid in stick nests high in trees. In flight, the zone-tailed hawk resembles the turkey vulture.

Little is known about this species, but population declines have occurred, with shooting and habitat destruction being the major problems. Within the study area, it can occasionally be found in the Jemez Mountains (Hubbard et al. 1978). This bird is a neotropical species and reaches its northern limits in the southwestern United States.

Ospreys

The osprey is on Group II of New Mexico's endangered list and Group III of Arizona's endangered list. This bird is a piscivore; almost nothing but fish appears in its diet. It usually nests in trees or on rock pinacles. Eggs are variable in color, ranging from white to reddish with heavy brown markings. Eggs average 2.4 x 1.8 inches (61 x 46 mm) (Reed 1965). Usual clutch size is two or three eggs.

The major cause of decline of this species appears to be chlorinated hydrocarbon pesticides which concentrate in fishes, and like the bald eagle and peregrine falcon, interferes with the calcium metabolism of the bird (Koplin 1971, Hubbard et al. 1978). Water pollution, disturbance, and shooting are also negative impacts.

This bird is a rare breeder in New Mexico (formerly bred in the Jemez Mountains), but occurs rather widely as a migrant. It has been observed in the San Juan Valley and at Navajo Dam, the Chuska Lakes, Morgan Lake, Acomita Lake, and Nutria No. 4 Reservoir on the Zuni Indian Reservation (Schmitt 1976, Kinsky 1977, T. Merkel 1978, personal communication). See Zarn (1974c) for further information on this species.

Sage Grouse

The sage grouse is in Group I of the New Mexico endangered list. This is the characteristic grouse of extensive areas of the Great Basin (Hubbard et al. 1978). It feeds on sagebrush leaves, forbs, grasses, and insects. Sage grouse are often found in flocks, and during the breeding season males perform elaborate courtship "dances" on the leks where females come for mating purposes (Johnsgard 1973, Hubbard et al. 1978). The nest is made on the ground usually under sagebrush. Clutch size ranges from 7-17. Eggs are grayish or drab green, averaging 2.17 x 1.5 inches (55 x 38 mm) (Reed 1965).

This species is common over much of its range. Colorado has had a hunting season on sage grouse since 1953 (Johnsgard 1973). In New Mexico, the species has apparently been extirpated from the Chama Valley since 1912 (Ligon 1961) and transplanted birds appear to have died out on the Jicarilla Apache Reservation and at Navajo Lake (Hubbard et al. 1978). Sagebrush habitat is quite extensive in New Mexico and a large portion of the north-central part of the study area is sagebrush habitat, but it appears to be inferior in quality, lacking the necessary forb species (Hubbard et al. 1978). New Mexico is the historic southern limit of this bird's range.

Red-headed Woodpecker

The red-headed woodpecker is on the New Mexico endangered list (Group II). Within the study area this bird is strictly associated with low elevation riparian woodland and planted groves of trees (Hubbard et al. 1978). The nest

is a hole excavated in a tree or utility pole. Four to six eggs are laid, averaging 1.0 x 0.75 inches (25.5 x 19 mm) (Reed 1965). Food is mostly insects.

A decline in the red-headed woodpecker population of the area has occurred, beginning in the 1920's (Hubbard et al. 1978). The usual problems of habitat destruction and persecution have caused some of the decline, but an additional factor is competition for nest holes with the starling (Hubbard et al. 1978). Starlings consistently take over holes from these and other woodpeckers after they are constructed.

Buff-breasted Flycatcher

The buff-breasted flycatcher is on the New Mexico (Group I) and Arizona (Group IV) endangered lists. This is a common bird in suitable habitat in Mexico and farther south. The species has not been verified in New Mexico since 1921 (Hubbard et al. 1978). It was observed in Valencia County in 1873 at El Morro. Factors responsbile for its decline are not clear, but fire protection and the resultant increase of understory in pine and pine-oak woodlands may be responsible (Phillips et al. 1964, Phillips 1968). The study area is the northern limit of this species' range.

Baird Sparrow

This bird is in Group II of the New Mexico endangered list. It is a shy ground nesting bird of grasslands, although in recent years there have been reports of it using alfalfa fields as well (Hubbard et al. 1978). Food consists of seeds and insects. It is a migrant, appearing in the area as early as the first week of August, but is rarely seen in spring.

This species has declined throughout its range, probably due to the effects of drought, agriculture, and grazing on the shortgrass plains where it breeds (Hubbard et al. 1978).

White Pelican

This species is on Colorado's threatened list. It is not known to breed within the study area, but occurs as a migrant (Bailey and Niedrach 1965, Hubbard 1978, Monson and Phillips 1978). These birds are piscivores. Average clutch size is two. Both adults incubate the eggs and care for the young. This species has been recorded from the San Juan Valley and at Red Lake on the Navajo Indian Reservation.

AMPHIBIANS

Jemez Mountains Salamander

A New Mexico endangered (Group II) species, the Jemez Mountains salamander is known from only a few localities in the Jemez Mountains of New Mexico. This salamander is very secretive, spending most of its life underground, hidden beneath rocks, or under or within rotten logs on north-facing slopes (Williams 1972a, Hubbard et al. 1978). The preferred habitat type is mixed conifer.

Although the Jemez Mountains salamander is not aquatic, it must remain moist at all times. Dessication is fatal because they have no lungs. Oxygen is acquired through the skin which must be moist for respiration to occur. Food consists of insects and other small invertebrates. Little is known about their life history. It is speculated that about eight eggs are laid and that the larval period is passed within the egg (Williams 1972a, Hubbard et al. 1978). Young emerge fully formed.

This species seems to be fairly numerous in several restricted localities within its range (Hubbard et al. 1978). Logging, overgrazing and trampling by livestock, severe forest fires, and excessive human disturbance may pose serious threats to the survival of this species.

Boreal Toad

The boreal toad is on the New Mexico endangered list (Group II). In New Mexico it is found exclusively in the San Juan Mountains in the vicinity of permanent water (Hubbard et al. 1978). Mating takes place in water and the eggs are deposited in water where the tadpoles remain until they transform. Breeding occurs from January to July, depending on latitude and elevation.

This species is abundant over much of its range, but in New Mexico it is very peripheral and of uncertain but probably low population density (Hubbard et al. 1978).

FISHES

Colorado Squawfish

The Colorado squawfish, included on the Federal list of endangered species, is our largest native Cyprinid, having attained unverified lengths of 6 ft (1.8 m), and weighing more than 80 lbs (36 kg). Historically, this species inhabited the main river channels of the entire Colorado River system from Mexico to Wyoming. The fish has virtually been extirpated as a naturally self-sustaining species in the lower Colorado below Glen Canyon Dam. They have also decined drastically in the San Juan drainage (Hubbard et al. 1978).

The alteration of practically the entire Colorado River for water development projects has severely changed flow patterns, temperature, turbidity, and fish species composition within the range of this species (Hubbard et al. 1978). Dams are barriers which prevent migration necessary for reproductive purposes. Nursery areas have been eliminated due to altered flow regimes. Drastic declines in the abundance and distribution of the bonytail and roundtail chubs and other prey species have also resulted from degradation of the system (Hubbard et al. 1978). Specimens have been collected in the vicinity of Navajo Dam, Rosa, New Mexico and in 1978, at Aneth, Utah.

Humpback Sucker

The status of the humpback sucker has recently been investigated and the listing process (threatened) has been initiated by the U.S. Fish and Wildlife Service. Although this species has never been collected in the San Juan

drainage of New Mexico, they have been collected at Mexican Hat, Utah and there are no barriers to prevent them from moving as far upstream as Navajo Dam.

Reproductive habits of this fish have been observed by Douglas (1952) and Jonez and Sumner (1954). Spawning occurs along shorelines or in bays from late winter to early summer. Eggs are attached to the bottom substrate. Foods eaten by humpbacks include algae and dipteran larve (Jonez and Sumner 1954), and planktonic crustaceans (Minckley 1973). The construction of dams on the Colorado River system is considered the major reason for the decline of this species.

Zuni Mountain Sucker

Although the taxonomic status of this species is as yet undetermined, it has nonetheless been placed on the New Mexico endangered list (Group II). It is found only in the Zuni Drainage. The life history of this species is not well known.

The primary cause for the endangerment of this species is an eradication program to rid the Zuni drainage of suckers (Hubbard et al. 1978). Habitat deterioration in the lower portion of the Zuni River drainage has also influenced the decline of this species. Merkel (1979, personal communication), believes that habitat deterioration is the major problem this fish faces, but efforts to eradicate green sunfish and fathead minnows from the lower part of the Zuni drainage have also contributed to its decline.

Bonytail Chub

The bonytail chub is on the New Mexico, Colorado, Arizona, and Utah endangered lists. Hubbard et al. (1978) stated that this fish has never been confirmed in New Mexico, but specimens with bonytail feature have been collected in the San Juan drainage. Further research by Hubbard and his associates indicates that this species has never occurred in New Mexico waters.[12]

Little is known of the reproductive habits of bonytail chubs, except that spawning occurs at approximately 64°F (18°C) (Vanicek and Kramer 1969). Adult bonytails feed primarily upon insects and plant debris.

Roundtail Chub

The roundtail chub is listed in Group II of the New Mexico endangered list. This species breeds from early spring to late summer. Foods consist primarily of aquatic terrestrial insects, filamentous algae, and, when the chub are large, other fishes are eaten (Minckley 1973).

Spawning appears to occur at 65°F (18.3°C) and higher, but no observations of actual spawning have been made and exact spawning locations have not been found (Vanicek and Kramer 1969).

[12]Stated by Mike Hatch, New Mexico Dept. Game and Fish, Santa Fe, in a presentation at the Arizona-New Mexico Section Meeting of the American Fisheries Society, 2 February, 1979.

The distribution of roundtail chub has become reduced and restricted throughout much of its former range (Hubbard et al. 1978). Possible reasons for the decline are competition with smallmouth bass and rainbow trout and predation by these and other large fish such as northern pike and largemouth bass (Kinsky 1977, Hubbard et al. 1978).

Colorado River Cutthroat Trout

This species is on Colorado's threatened list. The original distribution of this fish extended from the headwaters of the Colorado River downstream to Dirty Devil River, Utah, on the west and the San Juan drainage on the east (Behnke and Zarn 1976). A few remnant populations may exist in the headwaters of the San Juan in Colorado, but otherwise this species is no longer present within the study area. The only pure populations occur in Wyoming.

Little is known of the life history of this species. This fish spawns in the spring, as do all nondomesticated western trout of the genus Salmo. Increasing water temperature triggers reproduction. This fish is an obligatory stream spawner because of the necessity of gravel for nest construction and high oxygen tensions for the developing embryos (Behnke and Zarn 1976). Fry emerge from nests in late summer.

Hybridization caused by massive introduction of rainbow trout and subspecies of cutthroat trout into waters in which they were not native has caused the virtual elimination of pure populations of the Colorado River cutthroat (Behnke and Zarn 1976). Habitat loss and degradation as a result of irrigation projects, mining, logging, road building, and overgrazing have also taken their toll.

INVERTEBRATES

Blue-Black Silverspot Butterfly

The blue-black silverspot butterfly has been proposed by the U S. Fish and Wildlife Service to be listed as threatened. This species is restricted to isolated seeps and springs in the Colorado Plateau and Great Basin. They typically occur in spring-fed meadows or hillside seeps where violets, the larval food plant, grow. The blue-black silverspot butterfly occurs in the Chuska Mountains.

PLANTS

Three species of plants, which have been proposed for Federal listing as endangered species, occur on the study area: Sclerocactus mesa-verdae, Pediocactus knowltonii, and Erigeron rhizomatus.

Sclerocactus mesa-verdae is found in northwest San Juan County, New Mexico and southwest Montezuma County, Colorado. It typically occupies extremely dry, exposed hillsides usually with clay soils (Kinsky 1977) at 4,000-5,000 ft (1,319-1,524 m). Whitford and Spellenberg (1978) provide a good description of this species.

Pediocactus knowltonii has been recorded only from the Colorado-New Mexico border along the Los Pinos River in San Juan County, New Mexico. It is found in the more mesic sites among sagebrush and pinyon-juniper woodland at about 6,000 ft (1,829 m) (Whitford and Spellenberg 1978). A description of the plant is provided by Whitford and Spellenberg (1978).

Erigeron rhizomatus is a perennial forb which is known only from detrital, somewhat alkaline clay soils near Fort Wingate in McKinley County, New Mexico at an elevation of approximatey 7,400 ft (2,255 m) (Whitford and Spellenberg 1978). It is found in association with pinyon-juniper. Whitford and Spellenberg (1978) also provide a description of this plant.

Rangeland Resources International, Inc. (1978) and Whitford and Spellenberg (1978) have also listed the following plants as questionable (deserving of endangered or threatened status) status: Aquilegia micrantha var. mancosana, Astragalus accumbens, Astragalus deterior, Astragalus humillimus, Astragalus naturitensis, Astragalus schmollae, Atriplex pleiantha, Lesquerella pruinosa, Pediocactus papyracanthus, Petalostemum scariosum, and Stellaria irriqua.

KEY HABITATS

RIPARIAN HABITAT

Since most of the study area is composed of arid land, water and the habitat associated with water is very important to wildlife (see impacts section). All riparian areas should be considered key habitat. River bottoms in the Dolores River Project area were designated by Colorado Division of Wildlife as key areas for beaver, mink, short-tailed weasel, ring-tails, kit fox, and wintering bald eagles. The Dolores River drainage also contains prime elk winter range.

The importance of San Juan, Animas, and La Plata River drainages was described by Kinsky (1977:91) as follows:

> "The San Juan, Animas, and La Plata River drainages are uniquely important in water-short New Mexico. Permanent surface water, particularly riverine and associated riparian habitat, is seriously deficient in the state. The biological importance of the three-river complex is indisputable; its aquatic and riparian biota ranks among the best in the Southwest. The San Juan River is rated by some as one of the top ten trout streams in the United States."

These waterways are key habitat for several State or Federal endangered species. These include the mink, bald eagle, peregrine falcon, Mississippi kite, osprey, red-headed woodpecker, Colorado squawfish, humpback sucker, bonytail chub, Colorado River cutthroat trout, and possibly the zone-tailed hawk.

Rinconada Canyon, in Cibola National Forest, is considered key habitat for elk, deer, and wild turkey (F. Winger[13], personal communication). Other streams of prime importance to wildlife are Water Canyon and Lobo Spring.

Kinsky's (1977:91) statement of energy development and riparian habitat is also applicable to uranium development. He stated that:

> "In light of the extremely sensitive and irreplaceable nature of these resources, any energy development proposal that would adversely impact them should be discouraged. Riparian habitat in the area has already been reduced significantly; further destruction should not be permitted."

It is our opinion that strong measures be taken to manage riparian habitat on sound ecological bases considering the needs of the local and migratory wildlife which use these areas.

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[13]F. Winter, U.S. Forest Service, Cibola National Forest.

BIG GAME WINTER RANGE

Deer and elk populations are determined by the quantity and quality of available habitat, and winter range is the critical habitat in the mountainous West because of its relative small size and location in areas where land is in demand for other uses (Klemmedson 1967). This habitat categorization is true of deer and elk winter range within the study area, and we believe these areas should be given special consideration for the future in any type of land use planning. Locations of deer and elk winter range within the San Juan Basin are described in the mammals section of this report (pp. 13-18).

RAPTOR AREAS

River bottoms of the study area are important as loafing and hunting areas for bald eagles and osprey (Colorado Div. of Wildlife 1974, Hubbard 1978). Several key raptor habitat areas were discussed in a wildlife analysis of the Dolores River project areas done by the Colorado Division of Wildlife (1974). The following is taken from their report.

The Dolores River downstream from the proposed site of McPhee Reservoir to Slick Rock is key habitat for golden eagles. Four golden eagle nest sites are located along the precipitous cliffs of this section of the Dolores River.

Totten Reservoir and its adjacent habitat is an important concentration area for wintering bald eagles. A stand of cottonwood trees approximately 0.5 mi (0.8 km) east of the reservoir is a traditional roost site. Additional species which are present are red-tailed, rough-legged hawks, great horned owls, kestrels, marsh hawks, and occasionally prairie falcons, golden eagles, and during migration, osprey.

Narraguinniep Reservoir and its adjacent habitat is also an important roosting site for bald eagles. Concentrations are found in several large cottonwood trees on the north side of the reservoir. Other raptors such as rough-legged hawks, red-tailed hawks, Cooper hawks, sharp-shinned hawks, and occasionally migrant ospreys also utilize this site.

Rimrock on the west, north, and south sides of Mesa Verde National Park is key habitat for golden eagles and peregrine falcons. Thirteen golden eagle nests were located on these escarpments. These cliffs are also considered prime peregrine falcon nesting habitat although no nests were found.

PRAIRIE DOG TOWNS

Prairie dog towns should be considered as key habitat for black-footed ferrets. It has been assumed that the black-footed ferret, a Federally endangered species, is almost totally dependent upon prairie dogs (Hubbard et al. 1978). A new technique is being perfected to detect ferrets with the aid of dogs. The use of these dogs should enable wildlife managers to locate ferrets. All prairie dog towns should be considered key ferret habitat until they are checked by these dogs.

ALPINE TUNDRA

Alpine tundra habitat is found only on the highest peaks of the study area. It is considered key habitat for four reasons. First, very little is found in the southwestern United States. Secondly, it is a delicate environment which is slow to recover from disturbance. Thirdly, it is considered preferred habitat for the pika and yellowbelly marmot and nesting habitat for the horned lark, water pipit, black rosy finch, rock wren, and white-tailed ptarmigan (Garrison et al. 1977). Finally, these areas are considered prime watersheds (Garrison et al. 1977).

JEMEZ MOUNTAINS SALAMANDER HABITAT

The volcanic substratum surrounding Redondo Peak and the Valles Caldera in the Jemez Mountains, New Mexico, is key habitat for the Jemez Mountains salamander. In fact, it is the only habitat known for this species (see endangered species section). This portion of the study area is of utmost importance to this species and should be under strict protection.

ARID LAND SPRINGS

Springs which occur in otherwise dry areas are key habitat for a variety of wildlife. Two of these areas were described by Kinsky (1977).

The Max Lopez Spring is located along a shale outcropping on the southeastern boundary of the Star Lake-Bisti inventory area within Section 34, Township 19 North, Range 3 West.

During drought this spring is one of only two dependable water supplies available to wildlife for several miles around. Its setting among rugged cliffs and healthy stands of pinyon-juniper woodland make it attractive to many species of wildlife. Several raptors, such as the prairie falcon, red-tailed hawk, kestrel, and great horned owl have been observed perching and hunting in the immediate area. Even without these observations, such use is conspicuous by the typical "whitewash" on nearby cliffs and the presence of raptor pellets or castings at the base of the cliffs.

Eagle Spring is located within Section 33, Township 19 North, Range 3 West, about 2 mi (3.2 km) west of Max Lopez Spring. This spring is located in the sagebrush-pinyon-juniper ecotone. Its location makes it available to members of the sagebrush community such as pronghorn, numerous small birds and mammals, and species such as deer typically found in pinyon-juniper woodland. Kinsky (1977) suggested that a buffer zone of 0.25 mi (0.4 km) be established surrounding these springs.

Key areas already set aside for wildlife in the study area by the New Mexico Department of Game and Fish are listed in Table 6.

Table 6. New Mexico Department of Game and Fish Areas set aside for wildlife (Chisholm 1978).

County	Management area	Purpose	Size
San Juan	Jackson Lake Waterfowl Area	Migratory waterfowl	840 ac
San Juan	San Juan River Fishing Easement	Trout fishing	2 mi (lease)
San Juan	Navajo Dam Land and Wildlife Management Area	Recreation, wildlife	3,785 ac
McKinley (Cibola N.F.)	McGaffey Lake	Fishing, camping	14 ac
McKinley and Sandoval	Marquez Wildlife Area	Wildlife, hunting	14,500 ac
Valencia	Water Canyon Big Game Refuge	Big game, hunting	2,840 ac

RESULTS AND DISCUSSON OF FIELD OBSERVATIONS

WILDLIFE

Table 7 summarizes all wildlife observed in the vicinity of uranium mines and mills of the area. Mule deer were the only big game animal observed. Most native game species populations are extremely low due to poor range conditions (Howard 1978). Mule deer densities in the Crownpoint area probably range from 4-6 animals per section in pinyon-juniper habitat. Mule deer populations probably would be at least three times as great in similar vegetation that was in good condition.

The whitetail prairie dog was the most conspicuous and probably one of the most abundant mammals observed. Most mines located in grassland-desert shrub habitat had active prairie dog towns within 0.5 mi (0.8 km) of the mine site. One prairie dog town was located at the edge of a mill tailings pond (Sohio). Prairie dogs appear to be quite adaptable to the presence of humans; populations were observed within the city limits of Grants and Gallup.

Other rodents observed included the rock squirrel, spotted ground squirrel, whitetail antelope squirrel, cliff chipmunk, Ord kangaroo rat, woodrat, deer mouse, and porcupine. Rock squirrels, cliff chipmunks, and porcupines appeared to be common, while other species were observed only occasionally. Small rodents are generally quite secretive and often nocturnal in habit, consequently our observations are not a good indication of the abundance of these species.

Rabbit populations appear to be low, especially west of Ambrosia Lake. Desert cottontail and blacktail jackrabbit were the only species observed.

Although few were actually seen, coyote sign was observed regularly, particularly in dry washes of the grassland desert shrub type. A coyote den was located in an ore pile in the Ambrosia Lake area (Figure 4).

A red fox was sighted in pinyon-juniper habitat near the UNC mill at Churchrock. This observation is unusual because there are no published records of red fox being in this area. Gray fox were seen at the Jackpile mine and are probably found throughout the Grants Mineral Belt in suitable habitat.

Gamebirds observed near mine or mill sites included mallard, pintail, blue-winged teal, ruddy duck, coot, mourning dove, wild turkey, and scaled quail. Coots were observed on mine settling and mill tailings ponds. Blue-winged teal were also seen on tailings ponds. Other waterfowl were observed on stockponds in the vicinity of mines.

Wild turkey sign was observed near the Ray Williams mine at Sa Nos Tee and scaled quail were seen in the Ambrosia Lake area in salt cedar groves. Mourning dove appeared to be common, and were observed at almost every mine site.

Table 7. Wildlife observed at uranium mine and mill sites.

Species	Sa Nos Tee	Churchrock		Crownpoint		Ambrosia Lake		Laguna	
	PJ	G/DS	PJ	G/DS	PJ	G/DS	PJ	G/DS	PJ
Mammals									
Raccoon							X	X	
Badger		X							
Coyote		X		X	X	X		X	X
Red fox			X					X	
Gray fox									
Bobcat	X					X			
Whitetail prairie dog		X		X		X		X	X
Rock squirrel			X						X
Spotted ground squirrel		X		X		X			
Whitetail antelope squirrel							X		
Cliff chipmunk	X		X				X		X
Ord kangaroo rat		X		X		X			
Deer mouse						X			
Woodrat spp.						X	X		X
Porcupine	X		X		X	X	X		
Blacktail jackrabbit						X	X		
Desert cottontail	X	X	X	X	X	X	X	X	X
Mule deer	X	X	X		X	X	X		
Birds									
Great blue heron						X			
Mallard								X	
Pintail						X			
Blue-winged teal						X			
Ruddy duck								X	
Turkey vulture			X	X		X			
Red-tailed hawk						X			
Swainson hawk						X			
American kestrel		X	X	X		X	X	X	X
Scaled quail						X			
Wild turkey	X								

Table 7. (Continued)

Species	Sa Nos Tee PJ	Churchrock G/DS	Churchrock PJ	Crownpoint G/DS	Crownpoint PJ	Ambrosia Lake G/DS	Ambrosia Lake PJ	Laguna G/DS	Laguna PJ
American coot						X		X	
Killdeer						X		X	X
Spotted sandpiper		X				X			X
Forster tern						X			
Mourning dove	X	X	X	X	X	X	X	X	X
Burrowing owl		X				X			
Common nighthawk		X	X		X	X	X	X	X
White-throated swift			X			X			
Black-chinned hummingbird			X			X			X
Common flicker			X		X				
Western kingbird		X	X		X	X			X
Cassin kingbird			X		X				
Ash-throated flycatcher		X	X				X		
Say phoebe			X	X	X	X		X	X
Horned lark		X		X		X		X	X
Violet-green swallow	X	X	X			X	X	X	X
Cliff swallow		X				X			
Common raven	X	X	X	X	X	X	X	X	X
Common crow				X	X			X	
Pinyon jay	X	X	X		X	X	X		X
Mountain chickadee			X						
Plain titmouse			X				X		X
White-breasted nuthatch			X						
Bewick wren		X							
Canyon wren									X
Rock wren	X	X	X	X	X	X	X	X	X
Northern mockingbird					X				
American robin		X	X		X				
Western bluebird			X			X			
Mountain bluebird		X	X		X	X	X		

Table 7. (Continued)

Species	Sa Nos Tee PJ	Churchrock G/DS	Churchrock PJ	Crownpoint G/DS	Crownpoint PJ	Ambrosia Lake G/DS	Ambrosia Lake PJ	Laguna G/DS	Laguna PJ
Blue-gray gnatcatcher	X		X	X	X	X		X	X
Loggerhead shrike						X	X		X
Starling									X
Yellow warbler			X		X			X	
Yellow-rumped warbler								X	
MacGillivary warbler								X	
Wilson warbler				X		X		X	
Western meadowlark						X		X	
Yellow-headed blackbird						X			
Red-winged blackbird					X				X
Scott oriole									
Northern oriole		X		X		X			
Brewer blackbird						X		X	
Brown-headed cowbird						X		X	X
Blue grosbeak								X	
Lazuli bunting		X	X				X		X
Cassin finch			X			X			
House finch							X		
Green-tailed towhee									X
Brown towhee						X			X
Lark bunting								X	
Vesper sparrow			X		X	X		X	X
Lark sparrow						X			
Cassin sparrow				X		X			
Black-throated sparrow						X			
Sage sparrow					X				X
Tree sparrow			X	X	X	X	X		X
Chipping sparrow							X		X
Brewer sparrow									

Table 7. (Concluded)

Species	Sa Nos Tee	Churchrock		Crownpoint		Ambrosia Lake		Laguna	
	PJ	G/DS	PJ	G/DS	PJ	G/DS	PJ	G/DS	PJ
Amphibians and Reptiles									
Tiger salamander						X			
Red-spotted toad								X	X
Woodhouse's toad		X				X			
Western spadefoot				X		X			
Lesser earless lizard		X		X		X			
Many-lined skink			X						
Plateau whiptail			X						
Short-horned lizard			X				X	X	
Eastern fence lizard	X		X				X	X	
Prairie rattlesnake				X		X			
Fish									
Fathead minnow						X			
Brown trout						X			

Figure 4. Coyote den in ore pile, Ambrosia Lake (photo by S. Duzan).

Few raptors were observed in the vicinity of the mines. Five species; the turkey vulture, red-tailed hawk, Swainson hawk, American kestrel, and burrowing owl, were seen. The American kestrel appeared to be very common in both pinyon-juniper and grassland-desert shrub habitats. The turkey vulture also occurred regularly. Other species were seen infrequently. Burrowing owls were observed only at prairie dog towns.

Shorebirds such as the killdeer and spotted sandpiper appeared to be common in areas with water, including mine settling ponds, mill tailings ponds, and stock tanks.

Passerine birds were common around mine sites (Table 7). Some of the more conspicuous species were the western kingbird, Say phoebe, horned lark, violet-green swallow, rock wren, western and mountain bluebirds, loggerhead shrike, red-winged, Brewer, and yellow-headed blackbirds, brown-headed cowbird, house finch, brown towhee, lark sparrow, and chipping sparrow.

Horned larks were quite abundant in some grassland-desert shrub areas. Blackbirds, cowbirds, and swallows were usually seen only in the vicinity of water, in particular, the settling ponds at mines. These species were very rarely found in unmined areas or near mines which did not release water on the surface (Table 8).

Only nine species of herptiles were observed near mine or mill sites (Table 7). Short-horned lizards were common, as were lesser earless and eastern fence lizards. Plateau whiptails were conspicuous in the Laguna area. Prairie rattlesnakes were observed several times.

Table 8. Wildlife in actively mined and potential mining areas, Churchrock and Crownpoint, New Mexico

Species	Active	Potential
Mammals		
Badger		x
Coyote	x	x
Red fox	x	
Whitetail prairie dog		x
Rock squirrel	x	
Cliff chipmunk	x	
Ord kangaroo rat		x
Porcupine	x	
Desert cottontail	x	x
Mule deer	x	x
Birds		
Turkey vulture	x	
American kestrel	x	x
Spotted sandpiper	x	
Mourning dove	x	x
Burrowing owl		x
Common nighthawk	x	x
White-throated swift	x	
Black-chinned hummingbird	x	
Common flicker	x	
Western kingbird	x	x
Cassin kingbird	x	x
Ash-throated flycatcher	x	
Say phoebe	x	x
Violet-green swallow	x	
Cliff swallow	x	
Horned lark	x	x
Common raven	x	x
Common crow	x	
Pinyon jay	x	x
Plain titmouse	x	
Mountain chickadee	x	
White-breasted nuthatch	x	
Rock wren	x	x
Northern mockingbird		x
American robin	x	x
Western bluebird	x	x
Mountain bluebird	x	x
Blue-gray gnatcatcher	x	
Loggerhead shrike	x	x
Yellow-rumped warbler	x	
Western meadowlark		x
Scott oriole	x	

Table 8. (Concluded).

Species	Active	Potential
Brewer blackbird	x	
Cassin finch	x	
House finch	x	
Lark sparrow	x	x
Black-throated sparrow	x	x
Tree sparrow		x
Chipping sparrow	x	
Amphibians and Reptiles		
Woodhouse's toad	x	
Lesser earless lizard		x
Plateau whiptail	x	
Many-lined shink	x	
Eastern fence lizard	x	
Short-horned lizard	x	
Prairie rattlesnake		x

Amphibians such as Woodhouse's toad and the tiger salamander were observed in or near stock tanks and settling ponds near mines. Western spadefoot tadpoles were quite numerous in rainpools and stockponds. Red-spotted toads were observed in the Laguna area at Jackpile, UNC St. Anthony and Kerr-McGee Rio Puerco mines away from water.

Fathead minnows were observed in a stream at Ambrosia Lake, the source of which is an ion-exchange plant where mine water is treated with barium chloride. Several mining companies have stocked settling ponds with brown trout or catfish. For a list of species seen on the study area, but not in the vicinity of mine or mills, see Table 9.

No endangered species were observed in the vicinity of mines or mill. Potential habitat does exist for the black-footed ferret in the form of prairie dog towns, but no characteristic ferret signs, such as trenching were observed.

The only area where comparisons between active mines and potential mine sites could be made was the Churchrock and Crownpoint area. Potential mine sites were too far developed elsewhere. The major difference between these areas is the presence of surface water at the mine sites. As mentioned earlier, certain species of birds and amphibians were seen only in the vicinity of mine settling ponds. If the water and habitat provided by it were not present, these species would not occur either. Figure 5 shows an example of a typical mine settling pond. Effects of contaminated water from mines or mills upon wildlife was beyond the scope of this study.

Figure 5. Mine settling pond, Ambrosia Lake (photo by S. Duzan).

Table 9. Wildlife observed on study area but not on proposed or active mine and mill sites.

Species	Place observed
Mammals	
Bats[a]	Gallup, Grants
Black bear	Durango
Colorado chipmunk	Mt. Taylor
Tassel-eared squirrel	Mt. Taylor
Elk	Durango, Mt. Taylor
Birds	
Canada goose	San Juan Valley
Snow goose	San Juan Valley
Marsh hawk	Navajo Reservation, Mt. Taylor
Black tern	East of Grants
Rock dove	Gallup, Grants
Acorn woodpecker	Mt. Taylor
Willow flycatcher	Mt. Taylor
Barn swallow	Gallup, Grants
Steller jay	Chuska Mtns., Mt. Taylor
Black-billed magpie	San Juan Valley
Clark nutcracker	Mt. Taylor
Hermit thrush	Mt. Taylor
Great-tailed grackle	West of Grants
Western tanager	Mt. Taylor
Hepatic tanager	Mt. Taylor
Black-headed grosbeak	Mt. Taylor
House sparrow	Gallup, Grants

[a]Bats were observed in various places but no attempt was made to capture and identify them.

VEGETATION

Tables 10-18 summarize the vegetation characteristics of the various mine sites. Current active mines and potential mines are located in grassland-desert shrub and pinyon-juniper. Pinyon-juniper habitat was more diverse in regards to number of species and had a higher percentage of ground cover. Blue grama and galleta are the most common grasses in both habitat types, usually providing higher percentages of ground cover and composition than any other species. Pingue is an important perennial forb in both habitat types and annual forbs provide a large percentage of composition and cover. It should be noted that the 1978-79 winter and spring were atypical in regards to precipitation; much more fell than usual. As a result, vegetation growth was also above average.

Certain species were found growing in grassland-desert shrub habitat only on more mesic sites where water from mine dewatering procedures provided moisture. Salt cedar, scratchgrass, bulrush, and cattail are examples (Figure 5). Such areas provide a more diverse habitat for wildlife.

Importance values for most perennials are listed in Tables 10-18. The importance value, as described by Curtis and McIntosh (1951), is the sum of relative (%) density, relative dominance or height, and relative frequency of a plant species and is "an excellent indication of the vegetational importance of a species." The importance index is weighted toward density; the number of plants present exerts a greater effect on the index than does size. The importance value is not an index of the value of a particular plant species to wildlife, but when viewed in relation to importance values of other species in a habitat type, can give an indication of habitat quality. For example, in Tables 10-18 pinyon pine and one-seed juniper have relatively high importance values. These species provide good cover and shelter but limited forage for wildlife and, if other plants such as broom snakeweed or rubber rabbitbrush predominate in the understory with a high percentage of bare ground, the area can be considered poor wildlife habitat.

Blue grama and galleta usually had the highest importance values for a given habitat (Tables 10-18). However, these plants were in poor condition although quite numerous. The poor condition is indicated by an average height for blue grama of no more than 0.23 ft (0.07 m) except at Laguna where it averaged 0.5 ft (0.15 m) and 0.28 ft (0.09 m) in grassland-desert shrub and pinyon-juniper habitat, respectively.

Wildlife habitat in the vicinity of uranium mines generally is in poor condition and in some areas, such as the Navajo Reservation, it is very poor. This poor condition is primarily the result of overgrazing, and this problem must be dealt with before any significant improvement in wildlife habitat can occur.

Table 10. Summary of vegetation characteristics, Sa Nos Tee, pinyon-juniper habitat.

Species	Composition (%)	Cover (%)	Height (ft)	Density (No./ac)	Importance value
Canopy					
Mountain-mahogany	36.54	7.00	3.46	266	30.12
Pinyon pine	26.92	10.00	10.00	30	49.86
Bitterbrush	13.46		1.65	300	18.76
Fineleaf yucca	11.54		0.70	333	10.90
Littleleaf mockorange	9.62	1.00	4.10	300	29.81
Prickly-pear	1.92		0.43	133	11.93
Basal					
Slim tridens	16.33		1.05	5,000	68.37
Indian ricegrass	6.12		1.50	333	14.16
Blue grama	2.04				
Pingue	18.36		0.50	333	14.43
Penstemon	16.33		0.30	1,000	25.34
Bitterweed	10.20				
Skyrocket gilia	2.04				
Unidentified forbs	12.25		0.80	1,000	23.05
Annual forbs	16.33			666	
Bare ground		81.00			
Persistent litter		5.00			
Non-persistent litter		7.00			
Gravel		1.00			
Stone		4			
Bedrock		2			

Table 11. Summary of vegetation characteristics, Churchrock, grassland-desert shrub habitat.

Species	Composition (%)	Cover (%)	Height (ft)	Density (No./ac)	Importance value
Canopy					
Broom snakeweed	88.13	8.14	0.61	7,748	39.34
Greasewood	3.75	0.86	1.67	29	12.12
Big sagebrush	3.74	0.57	0.90	129	8.87
Pinyon pine	2.50	0.57	15.00	2	68.57
Rubber rabbitbrush	1.25	0.14	1.03	138	17.15
Winterfat	0.63		0.60	19	5.79
Basal					
Blue grama	31.36	5.15	0.16	33,143	87.74
Western wheatgrass	5.90		0.60	13,667	35.78
Bottlebrush squirreltail	0.56		0.73	1,333	13.28
Aster	0.74	0.15	0.25	952	5.86
Pingue	0.37		0.83	100	8.50
Annual forbs	58.12	3.01		102,952	
Annual grasses	2.95	0.30		6,476	
Bare ground		83.31			
Persistent litter		4.30			
Non-persistent litter		2.87			

Table 12. Summary of vegetation characteristics, Churchrock, pinyon-juniper habitat.

Species	Composition (%)	Cover (%)	Height (ft)	Density (No./ac)	Importance value
Canopy					
Pinyon pine	32.98	6.75	14.30	63	28.81
One-seed juniper	15.96	3.50	12.40	25	25.46
Broom snakeweed	15.96	0.25	0.68	241	5.68
Cliffrose	11.70	0.25	1.84	175	8.03
Big sagebrush	6.38	1.25	1.03	433	9.79
Ponderosa pine	3.61	4.00	49.00	8	56.78
Prickly-pear	4.25	0.50	0.27	275	7.54
Gambel oak	3.19	0.25			
Rubber rabbitbrush	2.15		0.82	191	9.39
Mountain-mahogany	1.06		1.30	8	2.62
Banana yucca	1.06				
Fineleaf yucca	1.06		0.60	16	1.84
Bullcods	0.64				
Basal					
Blue grama	28.85	3.00	0.16	29,159	51.59
Bottlebrush squirreltail	4.17		0.80	2,302	10.19
Galleta	4.17	0.25	0.57	5,333	12.41
Western wheatgrass	2.88		0.70	8,250	16.00
Indian ricegrass	0.96		0.68	1,083	7.00
Slim tridens	0.96				
Fendler three-awn	0.96				
Pingue	15.71	0.25	0.67	725	10.97
Sagewort	2.88		1.15	166	4.97
Aster	1.28		0.30	1,513	6.11
Fleabane	1.28		0.20	2,417	5.15
Bitterweed	1.28				
Onion	0.32				
Loco	0.32				
Eriogonum	0.32		0.60	333	2.33
Unidentified forbs	0.96				
Annual forbs	30.78			10,661	
Annual grasses	1.92			378	
Bare ground		67.25			
Persistent litter		11.13			
Non-persistent litter		4.50			
Gravel		9.63			
Cobble		1.25			
Stone		0.50			
Bedrock		1.75			

Table 13. Summary of vegetation characteristics, Crownpoint, grassland-desert shrub habitat.

Species	Composition (%)	Cover (%)	Height (ft)	Density (No./ac)	Importance value
Canopy					
Fourwing saltbush	52.99	2.16	2.26	220	29.29
Broom snakeweed	23.93	1.08	0.80	1,196	17.73
Pale wolfberry	11.97	0.25	1.23	354	13.99
Rubber rabbitbrush	5.13	0.25	1.30	96	10.41
Big sagebrush	5.13	0.08	1.33	45	11.66
Prickly-pear	0.85	0.08	0.35	29	4.51
Basal					
Galleta	14.46	2.33	0.75	8,341	32.92
Blue grama	12.93	1.92	0.23	9,268	30.46
Indian ricegrass	2.61	0.08	1.23	1,692	16.67
Bottlebrush squirreltail	1.96	0.25	0.74	545	11.40
Western wheatgrass	1.52	0.25	1.03	6,053	21.89
Fendler three-awn	0.76	0.08	0.70	567	7.71
Red three-awn	0.21				
Alkali Sacaton	2.82	0.17	2.30	4,918	25.00
Sand dropseed	2.72	0.08	0.70	250	5.91
Ring muhly	1.52	0.50	0.40	375	5.50
Globemallow	1.52		0.52	1,490	15.45
Aster	0.87	0.17	0.30	1,324	5.64
Dock	0.11	0.80			
Unidentified forbs	8.37	0.42	0.29	13,083	33.82
Annual forbs	47.28	1.83		25,871	
Annual grasses	0.33				
Bare ground		84.75			
Persistent litter		3.45			
Non-persistent litter		2.90			
Gravel		0.58			
Cobble		0.08			
Stone		0.08			

Table 14. Summary of vegetation characteristics, Crownpoint, pinyon-juniper habitat.

Species	Composition (%)	Cover (%)	Height (ft)	Density (No./ac)	Importance value
Canopy					
Big sagebrush	40.68	3.00	1.13	2,633	15.69
Pinyon pine	33.90	6.67	14.79	34	46.77
Broom snakeweed	7.24	0.67	0.63	467	6.26
One-seed juniper	5.08	1.67	7.80	13	26.68
Rubber rabbitbrush	3.39	0.33	0.80	344	6.65
Prickly-pear	3.39	0.33	0.23	44	5.19
Cliffrose	1.69	0.33	3.90	56	11.04
Fourwing saltbush	1.69		2.80	33	9.90
Green ephedra	1.69		3.50	11	10.07
Basal					
Blue grama	28.99	6.00	0.10	301,125	81.29
Galleta	12.61	1.33	0.60	9,584	6.83
Bottlebrush squirreltail	4.62	0.67	0.63	27,742	17.38
Indian ricegrass	1.68		1.00	2,522	7.65
Needle and thread	1.26		0.90	1,009	3.97
New Mexico feathergrass	0.84				
Sideoats grama	0.42				
Aster	5.88		0.23	28,246	13.45
Groundsel	3.78	1.00	0.43	23,202	11.20
Pingue	1.68	0.33	0.90	11,601	8.04
Globemallow	1.26		0.33	9,594	7.71
Sagewort	0.42				
Paintbrush	0.42		0.40	1,008	4.29
Moss	0.42	0.33		504	
Annual forbs	35.29	3.03		122,569	
Annual grasses	0.42			45,900	
Bare ground		54.33			
Persistent litter		9.33			
Non-persistent litter		9.33			
Gravel		7.33			
Cobble		0.33			
Stone		4.33			
Bedrock		2.33			

Table 15. Summary of vegetation characteristics, Ambrosia Lake-San Mateo, grassland-desert shrub habitat.

Species	Composition (%)	Cover (%)	Height (ft)	Density (No./ac)	Importance value
Canopy					
Broom snakeweed	41.46	1.90	0.71	1,996	16.58
Winterfat	20.12	0.90	0.74	1,984	14.40
Fourwing saltbush	15.24	0.95	1.80	233	11.26
Salt cedar	6.70	0.55	4.90	10	11.50
Big sagebrush	6.09	0.05	0.95	51	4.85
Rubber rabbitbrush	5.49	0.55	1.32	117	8.54
Prickly-pear	1.22		0.30	23	2.69
Cliffrose	1.22	0.05	4.40	5	9.65
One-seed juniper	1.22	0.05	7.87	1	18.69
Walkingstick cholla	0.61	0.05	1.50	11	3.43
Pinyon pine	0.61	0.05	11.50	1	23.88
Unidentified shrub	0.61	0.05	6.00	2	12.45
Basal					
Blue grama	36.77	11.55	0.16	103,455	82.24
Galleta	11.76	2.15	0.44	20,468	24.21
Scratchgrass	2.61	0.80	0.30	2,867	3.24
Bottlebrush squirreltail	2.50	0.50	0.61	4,300	9.35
Bulrush	0.72	0.15	1.20	5,575	6.34
Ring muhly	0.67	0.10	0.30	4,540	5.96
Indian ricegrass	0.55		0.60	80	1.67
Fendler three-awn	0.44				
Sand dropseed	0.33	0.15	0.57	577	3.17
Alkali sacaton	0.17		0.50	376	1.97
Western wheatgrass	2.16	0.20	0.93	6,690	8.58
Globemallow	0.44		0.40	1,911	5.76
Aster	0.39		0.32	1,911	4.77
Pingue	0.17		0.90	319	2.42
Fleabane	0.11		0.20	398	1.48
Annual forbs	39.93	3.10		99,393	
Annual grasses	0.11	3.05			
Bare ground		71.40			
Persistent litter		5.75			
Non-persistent litter		4.00			
Gravel		0.15			
Stone		0.10			
Bedrock		0.25			

Table 16. Summary of vegetation characteristics, Ambrosia Lake-San Mateo, pinyon-juniper habitat.

Species	Composition (%)	Cover (%)	Height (ft)	Density (No./ac)	Importance value
Canopy					
Broom snakeweed	70.00	5.67	0.52	6,744	25.78
One-seed juniper	18.00	2.33	9.90	25	46.61
Pinyon pine	10.00	2.00	10.60	27	44.63
Big sagebrush	2.00	0.33	1.10	1,038	6.57
Basal					
Blue grama	41.90	6.33	0.18	55,484	50.26
Galleta	18.97	1.33	0.36	64,563	56.86
Indian ricegrass	3.95	0.33	1.20	4,035	8.90
Little bluestem	1.98				
Slim tridens	1.58	0.33	0.50	4,035	6.52
Sand dropseed	1.19	0.33	0.95	3,026	13.91
Sand muhly	1.19	0.66	0.70	504	4.87
Bottlebrush squi-reltail	0.79		0.50	504	6.37
Western wheatgrass	0.79				
Fairway wheatgrass	0.40		1.10	4,035	8.56
Fendler three-awn	0.40				
Spike dropseed	0.40				
Wolftail	0.40				
Aster	1.98				
Louisiana sagebrush	1.58	0.33	0.20	2,522	4.51
Pingue	0.40		0.90	4,540	10.40
Sagewort	0.40				
Eriogonum	0.40				
Unidentified forbs	2.37	0.33	0.80	504	5.21
Annual forbs	18.53	2.33		51,933	
Annual grasses	0.40				
Bare ground		60.71			
Persistent litter		5.33			
Non-persistent litter		3.33			
Gravel		2.33			
Cobble		2.00			
Stone		3.00			
Bedrock		7.00			

Table 17. Summary of vegetation characteristics, Laguna, grassland-desert shrub habitat

Species	Composition (%)	Cover (%)	Height (ft)	Density (No./ac)	Importance value
Canopy					
Fourwing Saltbush	43.75	6.00	2.60	467	47.61
Broom snakeweed	56.25	3.00	0.78	2,533	30.92
Basal					
Galleta	12.94	1.50	0.65	27,237	62.95
Fendler three-awn	10.59	3.00	0.75	7,566	28.23
Sand dropseed	7.65		0.65	2,270	17.72
Alkali sacaton	5.88	1.50	0.70	1,513	12.97
Bottlebrush squirreltail	5.29	0.50	0.60	2,270	21.11
Western wheatgrass	4.12	0.50	0.50	1,513	11.14
Sideoats grama	3.53	0.50	1.50	757	18.88
Indian ricegrass	2.94		1.15	2,270	18.43
Blue grama	1.18	1.00	0.50	3,026	13.88
Tumblegrass	1.17		0.60	3,782	16.16
Ring muhly	0.59				
Annual forbs	44.12	3.00		68,093	
Bare ground		73.50			
Persistent litter		4.00			
Non-persistent litter		7.00			
Gravel		4.00			

Table 18. Summary of vegetation characteristics, Laguna, pinyon-juniper habitat.

Species	Composition (%)	Cover (%)	Height (ft)	Density (No./ac)	Importance value
Canopy					
Broom snakeweed	64.75	2.40	0.56	7,133	21.39
Big sagebrush	18.26	1.80	0.88	533	9.71
One-seed juniper	11.77	2.60	7.86	29	40.18
Pale wolfberry	1.74	0.20	1.10	167	7.22
Prickly-pear	1.74	0.20	0.42	67	4.63
Walkingstick Cholla	0.87	0.20	6.10	6	23.56
Wavyleaf Oak	0.87	0.20	3.00	7	12.10
Basal					
Galleta	32.16	2.40	0.54	28,448	33.78
Blue grama	31.55	5.40	0.28	48,422	46.33
Alkali sacaton	3.66	0.60	0.80	13,316	17.69
Fendler three-awn	3.34	0.20	0.64	4,237	12.52
Bottlebrush squirreltail	3.08	0.20	0.37	6,053	9.81
Ring muhly	2.83	1.00	0.30	13,921	16.28
Sand dropseed	0.51		0.40	302	2.71
Black grama	0.26		0.30	605	2.56
Sideoats grama	0.26		0.50	1,211	3.74
Slim tridens	0.26				
Muhly	0.26	0.20	0.60	3,026	6.43
Aster	5.36	0.40	0.26	5,750	10.19
Pingue	1.02		0.10	3,329	4.85
Bladderpod	1.02		0.10	3,329	4.81
Blackfoot daisy	0.77	0.20	0.60	302	3.44
Globemallow	0.26	0.20	0.70	605	4.04
Annual forbs	13.40	0.60		11,500	
Bare ground		60.00			
Persistent litter		4.40			
Non-persistent litter		1.40			
Gravel		10.80			
Cobble		3.80			
Stone		2.60			
Bedrock		5.60			

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READEX MICRO

IMPACTS

Uranium mining within the San Juan Basin will affect the wildlife resources of the region. The following discusses the effects of the uranium industry on wildlife. First, the general effects of human population increases, that precipitated by mining, milling, and other activities, are discussed. Secondly, the effects of uranium mining and milling are discussed, and finally, these impacts are related to the different levels of uranium development that have been predicted for the area from 1980 to 2000.

IMPACTS CAUSED BY INCREASE IN THE HUMAN POPULATION

If coal and uranium resources are exploited at maximum levels, the population of the San Juan Basin Regional Uranium Study area could increase by as much as 120% by the year 2000 (Gibson and Keen 1978). The population is expected to increase by 62% within this same time period even without new uranium or coal development. We believe that this increase in the human population and the resultant effects will have a greater impact upon fish and wildlife than uranium mining and milling per se.

These impacts will affect not only the survival of wildlife, but also the normal functioning of life processes such as growth, behavior, and reproduction (Neil et al. 1975). Habitat alteration, increased recreational use of the area, harassment by man and his domestic animals, increased pollution, and hazards caused by increased roads and traffic are among the problems to be faced with future development.

Habitat Alteration

Throughout much of the San Juan Basin, indigenous game species have extremely low population densities due to poor range conditions. Any activity which further destroys or decreases the value of habitat to wildlife would be detrimental to the species utilizing that habitat.

As the human population within the San Juan Basin expands, urbanization, more intensive agriculture, and industry will be major factors affecting wildlife habitat. The largest towns within the study area are Farmington, Gallup, Crownpoint, Milan, and Grants. Loss of habitat within the vicinity of these population centers will undoubtedly occur as a result of housing development, road construction, and industrial development. Increased and more intensive agriculture in these areas, and on the Navajo Reservation as a result of the Navajo Irrigation Project, will alter or destroy habitat for some species and possibly create new habitat for others.

Riparian habitat will be particularly vulnerable to destruction or alteration because of its proximity to and dependence upon water, and the generally better soil conditions. Anderson et al. (1977) stated that conversion of riparian habitat to agricultural use along the lower Colorado River has favored the brown-headed cowbird and reduced or eliminated breeding populations of the yellow warbler and the Bell vireo.

Many birds utilize riparian areas as winter habitat. Winter requirements of birds may differ from summer (breeding) requirements. Winter visitors tend to be specialists with large populations (Anderson and Ohmart 1977). Loss of the habitat in which they specialize could mean the total loss of a breeding population. Summer residents also tend to be specialized, although probably not to the same extent as winter residents (Anderson and Ohmart 1977).

The influence of riparian habitat upon wildlife is not limited to those species whose distribution is restricted to streamside vegetation (Carothers 1977). For example, Stevens et al. (1977) demonstrated that population densities of birds in habitats adjacent to riparian areas were influenced by the presence of the riparian areas. Not only are the riparian species adversely affected when a riparian habitat is removed or severely damaged, but wildlife productivity in adjacent habitats decreases.

Several endangered species depend heavily upon riparian habitat. Destruction of this vegetative type could jeopardize the existence of these species within the study area. Species included in this group are the mink, bald eagle, Mississippi kite, osprey, and red-headed woodpecker. See the endangered species section for more detailed descriptions of these species requirements.

The draining and clearing of riparian habitat will not only affect the terrestrial wildlife dependent upon it, but aquatic life as well. The riparian zone is very important in regards to fish habitat (Meehan et al. 1977). Much of the wood which forms the food base for stream biota comes from the riparian zone. This wood also plays an important role in shaping the stream and creating its habitat types. Streamside vegetation provides shade for the stream surface, thereby helping to regulate water temperature. Roots of woody and herbaceous plants provide streambank stability and help create overhanging banks, an important component of fish habitat. Streamside vegetation provides habitat for the later life stages of aquatic insects and for terrestrial insects utilized by fishes as food. When the riparian zone is affected by man's activities the quality of fish habitat obviously will also be adversely affected (Meehan et al. 1977).

Habitat alteration has already created a tremendous change in the fisheries resources of the San Juan Basin. Native cutthroat trout, Colorado squawfish, humpback sucker, roundtail chub, and the Zuni Mountain sucker populations have been drastically reduced as a result of factors discussed previously in the endangered species section. Further degradation of their environment would further reduce these populations.

The importance of maintaining the quality of surface water for fish and wildlife needs to be strongly emphasized. Every effort should be made to prevent further degradation and loss of this resource because of the limited amount of surface water available in the San Juan Basin. Lack of available water through increasing diversion for agricultural, municipal, and industrial uses will be the most critical factor limiting fish and wildlife in the future.

Increasing human populations may result in increased numbers of livestock. Livestock grazing has exerted a major influence on wildlife habitat in the past, and is expected to do so in the future. Overgrazing is a problem throughout much of the San Juan Basin. Grazing has a negative impact on riparian

zones (Ames 1977). Livestock exhibit a strong preference for riparian zones and if left on their own would graze these areas year-long. This would have a negative impact on fish and wildlife inhabiting the area.

Much of the grassland-desert shrub habitat within the study area has been severely overgrazed. Wildlife populations are low in these areas due to poor range conditions. Further destruction of habitat could eliminate some species, such as the pronghorn. Pronghorn habitat will possibly be affected in the Farmington and Grants areas and in Bernalillo and Sandoval counties northwest of Albuquerque. Expansion of urban areas, road buildings, and increased competition with livestock for forage could be detrimental to the pronghorn and its habitat.

There is literature (Taylor 1936, Monson and Kessler 1940, Smith 1940) which suggests that perennial grass ranges in good condition support lower densities of rodents than ranges in poor condition (Wood 1965). Vorhies and Taylor (1922), Bond (1945), Norris (1950), and Reynolds (1950) have indicated that rodents occupying poor condition ranges tend to prevent their recovery. It may be possible, therefore, that a decrease in local rodent populations may result in improved range conditions, if proper steps are taken to control and reduce other detrimental factors (i.e., overgrazing, erosion).

If local populations of rodents, rabbits, or insectivores are lost due to habitat destruction, predators such as coyotes, bobcats, raptors, and snakes which depend upon these prey species will either die or move to other areas.

An increase in the demand for meat could bring about the destruction or alteration of much pinyon-juniper habitat by cabling or other methods. Besides being very important to wildlife, pinyon-juniper woodlands are quite important for livestock grazing because their climate is usually favorable to range animals (Short and McCulloch 1977). These woodlands provide critical spring and fall range for cattle and sheep.

However, wildlife such as deer, elk, rabbits, coyotes, turkeys, quail, songbirds, and rodents have different habitat requirements than livestock. Short et al. (1977) showed that clearing of large areas of pinyon-juniper woodland decreased deer and elk use of these habitats, and Scott and Boeker (1977) demonstrated that large-scale pinyon-juniper eradication is harmful to wild turkeys.

Large-scale clearing of pinyon-juniper areas could reduce or eliminate the use of this habitat for breeding and nesting by the ferruginous, Swainson, and red-tailed hawks, American kestrel, horned owl, broad-tailed hummingbird, ash-throated flycatcher, Say phoebe, canyon wren, brown towhee, nighthawk, poorwill, and others (Swenson 1977).

Bird species diversity and numbers may also decrease with the loss of pinyon-juniper habitat. Swenson (1977) found that natural pinyon-juniper areas (not modified by cabling, or other management techniques) on the Cibola and Santa Fe National forests had a wider diversity and greater number of individual bird species, except sometimes during winter, than seeded clearings.

Increased logging activities and recreational use (increases the possibility of fire) in ponderosa pine and mixed conifer forests could affect local bird populations. Habitat changes in these vegetation types reduce the number of species and may affect densities of the original species occupying the area (Franzreb 1977). However, the altered habitat may be suitable for certain species which were not present before modification. Also, the habitat may be enhanced for some species which originally occurred in low numbers. Timber harvesting reduces tree densities, foliage volume availability, and amount of canopy, making less foliage available for foraging and nesting (Franzeb 1977). Slash piles, however, may provide additional foraging sites for certain species.

Timber harvesting can be beneficial to some species and detrimental to others. For example, properly designed harvests can increase herbage production and create diversified habitat for deer and elk (Patton 1974b). Logging could have negative impacts on several endangered species if precautions are not taken. The marten and Jemez Mountains salamander occur in mixed conifer forests and discretion is needed when logging in areas known to be inhabited by these animals. Wildfire is another factor detrimental to these species. The probability of wildlife occurring increases with an increase in logging and other human activities.

Ptarmigan distribution in Colorado has been greatly affected in recent years by the need for water and outdoor recreation (Braun 1971). Creation of water storage reservoirs in subalpine drainages floods large areas of willows and completely eliminates ptarmigan from these wintering areas. Ski areas are commonly developed in subalpine areas frequently extending to timberline. The removal of willows, trail cutting, and building of ski lodges are all detrimental to ptarmigan populations (Braun 1971). Future development in the San Juan Basin may precipitate the development of more ski areas and water impoundments.

Habitat alteration as a result of human activity will also affect species besides those mentioned above. Bat populations in many parts of the United States are declining (Reidinger 1976). Local populations could be adversely affected by the loss of roosting areas. Many bats are inhabitants of caves and may abandon them if much human activity, such as spelunking, occurs. Some bats may benefit from the increase in construction of houses and other buildings. Several species, i.e., little brown myotis and big brown bat, roost in buildings rather frequently.

It has been suggested that bat population declines are related to pesticides, to which bats are vulnerable because most are insectivorous and many have low reproductive potentials (Reidinger 1976). An increase in use of pesticides for agricultural purposes could be detrimental to local bat populations.

As human populations expand into mountainous areas, black bear and mountain lion ranges will probably become more restricted, and may eventually be eliminated from areas close to the larger population centers. These animals sometimes prey on domestic livestock, thus it is possible that interactions between lions, livestock, and people, and bears, livestock, and people will occur more frequently as populations of people and livestock expand.

Habitat alteration will be beneficial for some species of reptiles and amphibians and detrimental to others. Urbanization and agriculture may provide more habitat for amphibians and turtles if this brings about the construction of water impoundments. Local populations of herptiles may be destroyed by construction activities. Pollution of surface water by sewage, industrial waste, and agricultural waste will be detrimental to the amphibians and reptiles which depend on it.

Harassment

Harassment is defined by Neil et al. (1975:1) as "any activity of man and his associated domestic animals which increased the physiological costs of survival or decreases the probability of successful reproduction of wild animals." Under this definition almost any activity of man in habitat where wildlife exists is harassment. In this section, however, we define harassment as disturbance of wildlife by domestic animals and certain types of disturbances caused by man. Hunting and other "recreational" activities are discussed later.

Harassment of big game by dogs or people can be most detrimental at critical periods of the year, i.e., very cold weather in late winter, late pregnancy, and fawning (calving) time. Exertion during cold weather, particularly by weakened animals, is likely to precipitate emphysema and kill the animal (Geist 1971). Chasing advanced pregnant females through deeply crusted snow, causing them to strike their undersides on the snow crust or against hidden objects, may cause abortion. Abortion can also result from chasing pregnant females over snowless ground for long distances (Geist 1971).

Domestic dogs (pets) chasing and killing deer and elk is a growing problem in Colorado (Colorado Divsion of Wildlife 1973). Late winter and early spring are the critical periods. The problem increases with each new mountain subdivision.

Feral dogs are an ever-increasing problem on the Navajo Reservation (J. Antonio[14] 1978, personal communication). Morrison (1968) observed that a population of 300,000 feral dogs in Georgia had a major impact upon deer and domestic livestock. Morrison stated that dogs were thought to affect deer populations in three ways: (1) reduced reproduction due to harassment of does; (2) reduced survial of fawns because of heavy predation on fawns by free-ranging dogs; and (3) mortality of adult deer, either directly by killing them or indirectly by running them to death or preventing sufficient forage intake for maintenance.

Predation on small mammals and birds by dogs and cats has also been documented (Bowers 1953, Doucet 1973, Pils and Martin 1974). Although the extent of wildlife harassment by dogs and cats in the San Juan Basin is not known at this time, it does occur, and probably will increase as the population of the area, and the number of pet owners, increase.

[14]Navajo Fish and Wildlife, Window Rock, Arizona.

Harassment or disturbance by humans is a matter of particular concern with regard to endangered species. For example, declines of bald eagle populations have been partially attributed to direct human disturbance (Sprunt 1969). Stalmaster and Newman (1978) observed that human activity adversely affected the distribution and behavior of bald eagles wintering in northwest Washington.

Human disturbance has also been influential in the decline of other raptors such as the peregrine falcon and osprey. Shooting has been the major cause of osprey mortality in northern Idaho (Zarn 1974c). Campers, fishermen, loggers, and even birdwatchers who approach too close to osprey nests may cause loss of eggs or young. In the past, most peregrines have been tolerant of human intrusion into their nesting territories (Snow 1972). However, accumulated pesticides are producing abnormalities in behavior patterns and human activities may be much more detrimental than in the past (Snow 1972).

Frye and Olendorff (1976) list the following problems which could be encountered when nesting raptors and other "sensitive" bird species are disturbed:

(1) The parent birds may desert the eggs or young completely;

(2) Incidence of breakage, loss of humidity, cooling, overheating, and avian predation on eggs or trampling of young by parents may be increased;

(3) Newly hatched birds may be chilled or overheated and may die in absence of brooding;

(4) Older nestlings may leave the nest prematurely, damaging growing feathers, breaking bones, or may be forced to spend time on the ground where they are vulnerable to predation;

(5) Mammalian predators may follow human scent trails directly to eggs or young;

(6) The attention of other people may be attracted by the visitor's activities;

(7) Mishandling a nestling may injure the bird; and

(8) On cliffs, visitors may inadvertently knock rocks or other debris onto eggs or young.

The U.S. Fish and Wildlife Service and State wildlife agencies are knowledgeable about the locations of bald eagle and peregrine falcon nest sites. Any question in regards to possible harassment from mining activities or sightings of these birds should be addressed to the appropriate State wildlife agency or U.S. Fish and Wildlife Service. Also, the Colorado Division of Wildlife has begun a peregrine transplant program near Durango, Colorado, where young peregrines are placed in prairie falcon nests and raised by them.

Despite education efforts in their behalf, and the realization by many that herptiles are useful creatures, these animals are still destroyed because of human ignorance or vandalism (Conant 1975). Persecution of reptiles and amphibians also will probably increase numbers of people in the San Juan Basin.

Recreational Activities

It is expected that with the expanding human population, more leisure time, and modern vehicles and equipment for wilderness camping, more people will be taking advantage of recreational areas, consequently putting more pressure on wildlife populations.

Increased hunting and fishing pressure and poaching may have adverse impacts upon wildlife, particularly to game species residing on public lands. The demand for deer, elk, and pronghorn hunting within the basin will probably increase in the next 20 years, with the majority of the pressure occurring on National Forest land, because private land and Indian land often are not open to trespass by the general public.

New Mexico Department of Game and Fish (1978) has predicted the demand for hunting and fishing licenses in New Mexico through 1985 (Table 19). This shows a projected average increase of 11.5% in the demand for hunting and fishing licenses. In 1977, 11.7%, 23.0%, and 2.9% of the deer, elk, and pronghorn harvested, respectively, in New Mexico were taken within the study area (New Mexico Department Game and Fish 1977a, b, c).[15]

The key factor in regard to increased hunting and fishing pressure may be the amount and quality of habitat available to game. With proper management, if enough quality habitat is available, these species should continue to exist in huntable numbers. This conclusion applies to small game and big game. Campbell et al. (1973) observed that scaled quail populations readily survive, even during lean periods, under regulated hunting, and when habitat conditions permit, recover their numbers irrespective of whether or not hunting occrs.

An increase in other recreational activities such as snowmobiling and hiking could have adverse effects on wildlife. Several papers have been written on the ecological effects of snowmobiles. Snow cover is imporant to the survival of many small mammals which live beneath it because of the protection it affords from severe winter climate and predation. Jarvinen and Schmid (1971) found that reduction in snow depth and increases in snow density caused by snowmobiles reduces the insulative value of snow and increases the mechanical barrier to animal movements beneath the snow. These effects are most severe in areas that have been packed continuously since the first snowfall. Newmann and Merriam (1972) studied the ecological impacts of snowmobiles in Ontario and found snow structural changes by snowmobiles had significant effects on temperature gradients, water holding capacity, and melting rates. Snowshoe hare and red fox mobility and distribution were affected by snowmobiles, and damage to browse was significant.

[15]Although some management units are not entirely within the study area, they were included in the calculations. Thus the figures represented are slightly greater than the true values.

Table 19. Projected demand for hunting and fishing licenses in New Mexico, 1979 and 1985.

Species	Number of licenses		Increase (%)
	1979	1985	
Deer	99,990	113,000	11.5
Elk	24,330	27,490	11.4
Pronghorn	9,800	11,070	11.5
Black bear	11,200	12,660	11.5
Mountain lion	150	170	11.8
Wild turkey	20,640	23,320	11.5
Quail	26,750	30,230	11.5
Blue grouse	1,290	1,460	11.6
Pheasant	7,460	8,430	11.5
Dove	27,770	31,380	11.5
Bandtail pigeon	750	840	10.7
Waterfowl	10,480	11,840	11.5
Fish	187,710	214,755	12.6

Brown (1968) recognized human disturbance and harassment by all types of vehicles as a prime factor on both summer and winter elk range in Oregon. Moran (1973) considered the development of ski areas, cabins, and trailer parks quite detrimental to elk. Such developments in prime elk range in Michigan made these areas uninhabitable for elk. Moran stated that a behavioral characteristic, rather than a purely physiological requirement is involved.

Even such activities as hiking or backpacking can have detrimental effects upon wildlife. Neil et al. (1975) stated that one back-pack trip by one person through ptarmigan wintering habitat probably has little effect on a ptarmigan population, but repeated trips by numerous individuals could be disastrous.

Highways

Impacts upon wildlife populations caused by highways include mortalities, influences upon behavior, habitat destruction, and problems caused by de-icing chemicals and auto pollutants.

Mortality resulting from wild animal-vehicle collisions is one of the most direct and final impacts of highway use on wildlife (Leedy 1975). Wildlife mortality will increase as the volume of traffic increases and the highway network expands (Puglisi et al. 1974). Goodwin and Ward (1976) reported that between 1967 and 1975, 571 mule deer were killed along a 55 mi (88 km) stretch of Interstate 80 in Wyoming. This stretch of highway parallels the Snowy Range, presenting a barrier to seasonal migration and bisecting key winter range. Pojar et al. (1972) stated that between 5000 and 6000 deer-vehicle accidents occur annually in Colorado. In Pennsylvania, which is densely populated by humans and has a deer population, an average of 22,000 deer-vehicle collisons occur each year (Puglisi et al. 1974).

Elk and pronghorn are also killed by traffic each year (Thompson 1966, Martinka 1967), although the toll is not as high for these species as for deer. Ward (1975) reported a mean monthly mortality of 9.4 deer, 2.9 pronghorn, and 0.2 elk on a 55 mi (88 km) stretch of I-80 in Wyoming after it was opened. Ward et al. (1973) found that traffic on I-80 in Wyoming had little effect on elk behavior at distances of 300 yd (274 m) or more. However, the highway does act as a barrier to elk movement.

Greatest mortality of small mammals such as rabbits, squirrels, and skunks is associated with the increased activity that occurs during breeding season and periods of dispersal (Haugen 1944).

Aldrich (1975) estimated more than 57 million birds are killed annually by motor vehicles in the United States. Hodson (1962) suggested the following reasons why birds become highway casualties:

1) Feeding on remains of other victims or on earthworms which frequent road surfaces after a rain;

2) Dust-bathing or taking grit from roads;

3) Low-flying birds being hit as they cross roads;

4) Displaying on the road during breeding season; and

5) Striking electric wires, then falling to the road and being hit.

Amphibians, particularly toads, are run over in great numbers by vehicles when they cross the road during breeding season (van Gelder 1973).

De-icing chemicals used on roads can have adverse impacts upon wildlife. Field et al. (1974) stated that ferric ferrocyanide and sodium ferrocyanide, which are anticaking agents common to road salt, are soluble in water and can generate cyanide in the presence of sunlight. The ultimate fate of these cyanides is unknown. Hanes et al. (1970) observed that cyanide ions are extremely toxic, especially to fish. Hanes also stated that a rust inhibitor added to de-icing salts contains phosphorus which could stimulate aquatic plant growth and algae blooms.

Excess concentrations of heavy metals, particularly lead, can occur as a result of heavy traffic use. Sylvester and De Walls (1972) concluded that a major portion of vehicle emissions are carried off the road surface by air currents and water. If they settle on the surface, most particles are retained by the soil. Motto et al. (1970) found that lead in soils and plants sampled along heavily traveled highways tended to increase with traffic volume and decrease with distance from the highway.

Giles et al. (1973) and Price et al. (1974) provided evidence of lead accumulation by insects in areas of high traffic density. Mierau and Favara (1975) found increased lead concentrations in bones of roadside mice in Colorado, but could not demonstrate lead poisoning in these mice. The exposure level required to produce recognizable lead poisoning in captive deer mice was approximately five times greater than that encountered by the wild roadside population.

The most obvious impact of highway construction upon wildlife is the clearing, grading, and surfacing of wildlife habitat. Klemmedson (1967) stated that new highways sometimes pass through winter range of big game destroying this habitat. Brown (1968) observed that all weather roads on winter range are "one of the most serious threats to the future of Rocky Mountain elk herds." In order to minimize winter maintenance, highways are often located on south slopes, much to the detriment of winter range.

Erosion and sedimentation resulting from highway construction can be detrimental to fish resources. Anderson (1974), in a study of sediment deposition in California reservoirs, found that roads located near streams contributed the most to deposition and, of these roads, improved secondary roads were the greatest contributors. Whitney and Bailey (1959), studied the detrimental effects of highways and construction on a Montana stream and found reductions in game fish, including trout, amounted to 94% in both numbers and weight of the large-sized fish, and 85% in number and 75% in weight of small-sized fish.

Stream channelization is sometimes done to increase the rate of flow in streams and sometimes to obtain road-building material (Leedy 1975). The removal of bottom substrate would be detrimental to those fishes or other aquatic organisms that depend upon it for their life necessities.

IMPACTS OF URANIUM MINING AND MILLING

Habitat Alteration

Mining and milling will disturb the soil and remove forage plants from production in the immediate area where mining and milling operations take place (Rangeland Resources International, Inc. 1978). Nesting, breeding, and escape cover for wildlife would also be lost. Most mines and mills are and will be located in grassland-desert shrub or pinyon-juniper habitats. Although the habitat lost due to uranium operations will be small in comparison to the total acreage of these habitats within the San Juan Basin, the loss could be significant to local populations of wildlife. Loss of deer and elk habitat, potential black-footed ferret habitat, and the disturbance of peregrine eyries are legitimate causes of concern. Some ponderosa pine and mixed conifer habitat may also be lost as a result of mining and milling, particularly in the Grants-Mt. Taylor area.

There are, however, possible benefits for wildlife which may be derived from uranium operations. Reclamation of abandoned mine and mill sites could provide improved forage conditions if proper techniques and species are used and the necessary precautions are taken to prevent overgrazing (Aldon and Garcia 1971, Aldon 1978).

Mine dewatering could prove beneficial to wildlife if the water which is released to the environment is of acceptable quality for their use. In an environment where surface water is scarce, the addition of more could prove beneficial, even if only for the period of the life of the mine ($\bar{x}$ = 20 yrs). Observations on this subject were discussed previously.

Under certain conditions mine dewatering could also be detrimental to wildlife. Contamination of an aquifer by poor-quality water from other aquifers is a possibility (Kunkler 1978). Kunkler stated that it is likely that many aquifers containing good-quality water have already been contaminated by test holes and wells because the test holes were improperly plugged and the wells improperly cased. The effects could be detrimental if these contaminated aquifers provide water to springs or wells which wildlife utilize. Dewatering of an aquifer could also cause springs or wells fed by it to dry up.

Lyford (1979) has predicted a possible drawdown of 4000 ft (1219 m) near the deepest mines in the Morrison formation by 2000, and a reduction in flow in the San Juan River of 0.03 ft^3 (0.0008 m^3)/sec. Flow towards the Rio Grande may be reduced by as much as 0.5 ft^3 (0.01 m^3)/sec. Reductions in flow of this magnitude would have negligible effects upon the aquatic life of these river systems.

Use of the in-situ method of mining could possibly contaminate aquifers via the injection solution. More study on the ecological effects of this method will be needed to determine its safety if it is to be used on a regular basis within the San Juan Basin.

Surface mining is much more destructive to wildlife habitat than is underground mining. Large areas of vegetation and topsoil are removed and large amounts of waste rock are produced (Figure 6). If not properly

stabilized, the potential exists for sediment to be carried into streams, by runoff from these waste rock piles, to the detriment of aquatic life.

Figure 6. Open pit uranium mine, Laguna (Photo by S. Duzan).

However, when properly reclaimed, surface mining operations can result in productive wildlife habitat. The use of native species and proper technique is the key. Kelly (1979) discussed in detail the revegetation of open pit uranium mine spoils.

Mine ventilation shafts are a possible source of radiation contamination of the atmosphere, vegetation, and the food chain. These possibilities and their consequences need to be investigated.

Mill Ponds and Tailings

Uranium mill ponds and tailings piles are major objects of concern. Millponds are dilute sulfuric acid (H_2SO_4) (Kunkler 1978) which is strong enough to retain its basic chemical properties and some of its corrosive power (pH about 2). Kunkler considered the toxity of millpond acid senseless to speculate because "no animal will consume it." However, there have been reports of waterfowl landing on these ponds and being injured as a result (A. Kinsky[16] 1978, personal communication), and we have observed blue-winged teal, coot, and the Forster tern on these ponds. The extent of use of these ponds by waterfowl and other wildlife should be thoroughly investigated before any broad generalizations are made about their use.

[16]U.S. Fish and Wildlife Service, Albuquerque, N.M.

Mill tailings represent a potential hazard to wildlife. Particular attention needs to be paid to the naturally occurring radionuclides of the 238U (Uraniun-238) natural decay series. Among the decay series, 222Rn (Radon-222) and its daughters have been implicated as significant radiation hazards (Dreesen et al. 1978). Radium 226 poses an ingestion hazard comparatively greater than most radionuclides (Sorenson and Marston no date). Chemically it behaves similar to calcium, an essential element, and consequently is assimilated by plants and animals. Radium 226, an alpha emitter, lodges tightly in the bone matrix and has caused cancer in humans. It is of more concern than other radionuclides in mill tailings because of food-chain transport processes.

Toxic elements such as Se, Mo, As, and V are also present in many tailings (Dreesen et al. 1978, Rangeland Resources International, Inc. 1978). Although Se and Mo are essential elements in the diets of livestock, only very small amounts are required (0.1 mg/kg or less, dry matter basis) (National Academy of Sciences 1976). Selenium has been identified as an essential trace element in the diets of cattle, sheep, swine, horses, chickens, turkeys, quail, and dogs (National Academy of Sciences 1971).

When these elements migrate into the soil, the uptake of these contaminants by vegetation is of considerable significance to foodchains (Dreesen et al. 1978). In herbivore foodchains, problems of toxicity and further bioaccumulation become significant. Molybdenosis has been diagnosed in cattle grazing in uranium mining areas in Texas (Dollahite et al. 1972), and selenium poisoning is suspected to be responsible for sheep mortalities in a uranium ore outcrop area in New Mexico (Rapaport 1963). Selenium toxicity may occur when livestock consume forage containing 10-30 ppm Se (dry matter basis) (National Academy of Sciences 1976). It is possible that wildlife such as deer, elk, rabbits, and rodents could be similarly affected. However, more research needs to be done before conclusions can be made.

Kelley (1979) found that vegetation grown on uranium tailings piles in New Mexico contained higher concentrations of selenium, arsenic, lead, and copper than did vegetation growing on adjacent rangeland. For example, bottlebrush squirreltail from tailings piles contained selenium in concentrations averaging as high as 60.9 ppm, while on adjacent rangeland 1.9 ppm was the maximum concentration found in the same plant species. Likewise, alkali sacaton and fourwing saltbush from tailings contained selenium concentrations of 4.3 and 3.6 ppm respectively, while 0.3 and 0.8 ppm were the highest reported for these species on nearby rangeland.

In detrital food chains, these elements may concentrate in the humus horizon of the soil (Dreesen et al. 1978). The accumulation of these contaminants in the upper soil horizons could inhibit mineralization of organic matter via toxic effects on soil microorganisms or soil invertebrates.

Many transport mechanisms can move tailings and associated contaminants into the environment. Erosion by wind and water has been noted where tailing piles have not been well maintained (Dreesen et al. 1978). Other sources of dispersion are leaching of contaminants followed by seepage of contaminated ground water from tailings disposal sites or runoff from tailings piles. Breaks sometimes occur in the tailings pile dike. An example is the dam break at the United Nuclear Churchrock mill in July 1979.

The uptake of contaminants by vegetation, the consumption of this vegetation by wildlife, and the consumption of wildlife by people also may be a significant transport process. Dressen et al. (1978) stated, however, that uptake by vegetation is probably a minor transport process when compared to the erosion of bare tailings. If soil cover over a tailings pile is deep enough to prevent roots or moisture, or both, from penetrating into tailings, little contaminant uptake should occur.

The possibility of small mammals or other burrowing animals digging into tailings piles, and their possible contamination and spread into the food chain, deserves consideration. Anaconda Company has conducted some research on this subject, but results are not yet available to the public.

Release of large quantities of spent leach solution with tailings provides a potential mechanism for contaminant transport (Dreesen et al. 1978). At inactive tailings piles, the sources of solution which could act as an agent for ground water transport of contaminants include precipitation, collected surface runoff, and offpile sources. Seepage of contaminated water from mill tailings ponds has been reported by Kaufmann et al. (1976). This seepage represents potential pollutants of ground and surface waters, and if preset in sufficient concentrations, could be detrimental to aquatic life.

URANIUM PRODUCTION DEVELOPMENT

Three levels of uranium development are being projected for the years 1985-2000. Table 20, taken from Gibson (no date), shows the number of uranium mines and mills predicted for each level of development. Without knowing the exact locations of future mines and mills it is impossible to make accurate assessments of the specific effects of uranium development, on local wildlife popualtions, for the levels of activity indicated in Table 20. However, some generalizations can be made.

No Further Development

1985. With no further development mine numbers will have decreased to 14 and all 6 mills will still be in operation. Approximately 3080 acres (1246 ha)[17] of potential wildlife habitat, mostly in grassland-desert shrub and pinyon-juniper, will be lost to these mines and mills. Proper reclamation of abandoned mine sites would result in improved habitat for local populations of rabbits, rodents, some birds (including Fringillids), deer, and the predators which depend on these species.

1990. Nine mines and six mills will be in operation. Habitat loss to wildlife would approximate 2730 acres (1105 ha). Most of this will be grassland-desert shrub or pinyon-juniper. More habitat and forage will be available for wildlife if proper reclamation procedures are followed.

2000. Three mines and six mills will be in operation. Habitat loss will approximate 2310 acres (935 ha). An additional 420 acres (170 ha) of habitat could be reclaimed over that of 1990.

[17]Based on figures supplied by Rangeland Resources International, Inc. (1978:203).

Table 20. Projected numbers of mines and mills for 1985, 1990, and 2000 at three levels of uranium development (Gibson no date).

Rate of development - year	Mines	Mills
No further development		
1985	14	6
1990	9	6[a]
2000	3	6[a]
Moderate development		
1985	33	10
1990	48	11
2000	72	15
High development		
1985	57	12
1990	80	16
2000	105	22

[a]Assuming ore is acquired from outside the San Juan Basin to keep current mills operating.

Moderate Uranium Development

1985. With moderate uranium development, 33 mines and 10 mills are predicted to be in operation by 1985. Habitat loss would approximate 5810 ac (2351 ha), mostly in grassland-desert shrub and pinyon-juniper, although some ponderosa pine and mixed conifer habitat may also be lost. Loss of forested areas will occur mostly in the Mt. Taylor region and Chuska Mountains. With the development of new mines or mills, the potential increases for loss of key habitats, such as deer and elk winter range, prairie dog towns, and nesting and wintering sites of endangered raptors. Also, the potential for contamination of surface water greatly increases.

1990. The 48 mines and 11 mills which are predicted to be in operation at this time will account for a loss of 7210 acres (2918 ha) of habitat.

2000. At this time, 72 mines and 15 mills will account for a loss of approximately 10,290 acres (4164 ha) of wildlife habitat.

High Uranium Development

1985. By 1985, at this rate of development, 57 mines and 12 mills will be in operation. Approximately 8190 acres (3314 ha) of habitat will be lost. Again, this will be mainly grassland-desert shrub and pinyon-juniper, but some loss of forest types will probably occur. The Mt. Taylor region and the Chuskas stand out as being particularly vulnerable. These are the areas where wildlife will probably suffer most fron uranium development.

1990. Operational mines and mills will number 80 and 16, respectively. Approximately 11,200 acres (4532 ha) of habitat will be lost to mining and milling activities.

2000. In the year 2000, at the high rate of uranium development, 105 mines and 22 mills will be operational. Approximately 15,050 acres (6091 ha) of habitat will be lost. Obviously, this rate of development will be the most detrimental to wildlife. Habitat loss and other factors will be at a maximum at this level. It should again be emphasized that, although the amount of habitat lost due to uranium mining may seem small in proportion to the total amount available, this habitat could be very important in regard to local wildlife populations. Where the future mines and mills are located will determine their effect on the fish and wildlife resources of the San Juan Basin.

RECOMMENDATIONS

1. A long-term study of several years duration should be conducted on various aspects of uranium mining and milling. Information on this subject is sadly lacking. Included in this study should be investigations of (a) uptake of toxic and radioactive trace elements by vegetation growing on tailings, utilization of this vegetation by wildlife, and the spread of these toxic and radioactive materials through the food chain; (b) the extent of use of mill tailings ponds by wildlife, particularly waterfowl and other water associated birds and the effects of the detrimental qualitites of this water upon them; (c) the extent of use of mine settling ponds by birds and other wildlife and the effects of this use on these animals. (also survival and growth should be studied and tissue of fish stocked in these ponds should be analyzed); (d) effects of radiation from underground mine ventilation shafts upon adjacent vegetation and wildlife that consumes the vegetation; (e) effects of drawdown of aquifers upon surface water (springs, seeps) within the study area. Will mine dewatering at the predicted rates cause springs, which are valuable to wildlife, to dry up?

2. Surface water of suitable quality should be made as attractive as possible for waterfowl and other wildlife, especially water located near mill tailings ponds. This water will lure wildlife away from tailings ponds and eliminate some of wildlife's usage of them.

3. Chain link fences should be erected around all tailings areas, preferably 7-8 ft (2.1-2.9 m) high. Four-strand barbed wire will not keep wildlife out (Figure 7). Similar fencing should be placed around ventilation shafts (minimum of 25 yd [23 m] radius).

4. Efforts should be made to educate local people on the effects of overgrazing upon the range resource and wildlife. Managed grazing systems should be initiated.

5. Proper reclamation procedures should be used on test sites, mine sites, and tailings areas. Research is still needed to determine the best methods and species for reclamation of tailings.

Figure 7. Fencing around mill tailings, Ambrosia Lake (Photo by S. Duzan).

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APPENDIX A

Table A1. Species habitat relationships of mammals occurring in the study area.

Order-common name[a]	Scientific name	Habitat type[b] G/DS	PJ	PP	MC	A	R
Insectivora							
Masked shrew[a]	Sorex cinereus			X	X		X
Merriam shrew	Sorex merriami	X	X	X	X		X
Vargrant shrew	Sorex vagrans			X	X	X	X
Dwarf shrew	Sorex nanus			X	X	X	
Northern water shrew	Sorex palustris	X	X	XX	X	X	X
Desert shrew	Notiosorex crawfordi	X	X	X			X
Chiroptera							
Yuma myotis	Myotis yumanensis	X	X				X
Little brown myotis	Myotis lucifugus	X	X	X	X		X
Long-eared myotis	Myotis evotis				X	X	
Fringed myotis	Myotis thysanodes	X	X	X	X		X
Long-legged myotis	Myotis volans	X	X	XX	X	X	X
California myotis	Myotis californicus	X	X	X			X
Small-footed myotis	Myotis subulatus	X	X	XX	X		X
Silver-haired bat	Lasionycteris noctivagans	X	X	XX	X	X	X
Western pipistrel	Pipistrellus hesperus	X	X	X			X
Big brown bat	Eptesicus fuscus		X	XX	X		X
Hoary bat	Lasiurus cinereus		X	X	X	X	X
Spotted bat	Euderma maculata		X	X	X		
Western big-eared bat	Plecotus townsendi	X	X	XX	X		X
Pallid bat	Antrozous pallidus	XX	X	X			X
Mexican freetail bat	Tadarida brasiliensis	X	X	X			X
Big freetail bat	Tadarida molossa	X	X	X			X
Carnivora							
Black bear	Ursus americanus		X	X	X	X	X
Raccoon	Procyon lotor	X	X	X	X	X	XX
Ringtail	Bassariscus astutus	X	X				
Marten	Martes americana				XX	X	
Shorttail weasel	Mustela erminea			X	X	X	
Longtail weasel	Mustela frenata	X	X	X	X	X	
Black-footed ferret	Mustela nigripes	X	X	X	X		X
Mink	Mustela vison	X	X	X	X		XX
Badger	Taxidea taxus	XX	X	X	X	X	X
Spotted skunk	Spilogale putorius	X	X	X			X
Striped skunk	Mephitis mephitis	X	X	X	X	X	X
Hog-nosed skunk	Conepatus leuconotus	XX	X	X			
Coyote	Canis latrans	XX	X	X	X	X	X
Red fox	Vulpes fulva	X	X	X	X		X
Kit fox	Vulpes macrotis	X					
Gray fox	Urocyon cinereoargenteus	X	X	X	X	X	X
Mountain lion	Felis concolor	X	X	X	X	X	X
Bobcat	Lynx rufus	X	X	X	X	X	X

Table A1. (Continued)

Order-common name[a]	Scientific name	Habitat type[b] G/DS	PJ	PP	MC	A	R
Rodentia							
Yellowbelly marmot	Marmota flaviventris		X	X	X	XX	
Whitetail prairie dog	Cynomys gunnisoni	XX	X	X	X		
Rock squirrel	Citellus variegatus	X	X	X	X		X
Spotted ground squirrel	Citellus spilosoma	X					
Golden-mantled ground squirrel	Citellus lateralis		X	X	X	X	
Thirteen-lined ground squirrel	Citellus tridecemlineatus	X					
Whitetail antelope squirrel	Ammospermophilus leucurus	XX	X				
Least chipmunk	Eutamias minimus			X	XX	X	
Cliff chipmunk	Eutamias dorsalis		XX	X	X	X	
Colorado chipmunk	Eutamias quadrivittatus		X	XX	X	X	
Tassel-eared squirrel	Sciurus aberti			XX	X		
Red squirrel	Tamiasciurus hudsonicus			X	XX		
Valley pocket gopher	Thomomys bottae	X	X	X	X		X
Northern pocket gopher	Thomomys talpoides			X	X	X	
Plains pocket mouse	Perognathus flavescens	XX	X				
Silky pocket mouse	Perognathus flavus	XX	X				
Apache pocket mouse	Perognathus apache	X					
Rock pocket mouse	Perognathus intermedius	X					
Bannertail kangaroo rat	Dipodomys spectabilis	X					
Ord kangaroo rat	Dipodomys ordi	XX	X				
Merriam kangaroo rat	Dipodomys merriami	X					
Beaver	Castor canadensis		X	X	X	X	XX
Western harvest mouse	Reithrodontomys megalotis	X	X	X	X		X
Canyon mouse	Peromyscus crinitus		X				
Deer mouse	Peromyscus maniculatus	X	X	X	X		X
White-footed mouse	Peromyscus leucopus	X					
Brush mouse	Peromyscus boylei		X	X	X		
Pinyon mouse	Peromyscus truei	X	XX				
Rock mouse	Peromyscus difficilis		X				
Northern grasshopper mouse	Onychomys leucogaster	XX	X				
Southern plains woodrat	Neotoma micropus	X					
Whitethroat woodrat	Neotoma albigula	X	X	X	X		
Stephen's woodrat	Neotoma stephensi		X				
Mexican woodrat	Neotoma mexicana		X	X	XX		
Bushytail woodrat	Neotoma cinerea		X	X	XX	X	
Mountain phenacomys	Phenacomys intermedius				X	X	
Boreal redback vole	Clethrionomys gapperi				X	X	
Meadow vole	Microtus pennsylvanicus			X	X		XX
Mountain vole	Microtus montanus			X	X		
Longtail vole	Microtus longicaudus			X	XX	X	X
Mexican vole	Microtus mexicanus		X	X	X	X	
Muskrat	Ondatra zibethica	X	X	X	X		XX
House mouse	Mus musculus	X	X	X	X		X
Norway rat	Rattus norvegicus	X					X
Western jumping mouse	Zapus princeps			X	X		X
Porcupine	Erethizon dorsatum	X	X	XX	X	X	X

Table A1. (Concluded)

Order-common name[a]	Scientific name	Habitat type[b] G/DS	PJ	PP	MC	A	R
Lagomorpha							
Pika	Ochotona princeps				X	XX	
Snowshoe hare	Lepus americanus				X		
Whitetail jackrabbit	Lepus townsendi			X	X	X	
Blacktail jackrabbit	Lepus californicus	XX	X	X			
Eastern cottontail	Sylvilagus floridanus		X	X	X		
Mountain cottontail	Sylvilagus nuttalli			X	X	X	X
Desert cottontail	Sylvilagus auduboni	X	X				
Artiodactyla							
Elk	Cervus canadensis		X	X	X	X	
Mule deer	Odocoileus hemionusi	X	X	X	X	X	X
Whitetail deer	Odocoileus virginianus		X	X	X		X
Pronghorn	Antilocapra americana	XX					
Bighorn sheep	Ovis canadensis				X	X	
Barbary sheep[c]	Ammotragus lervia		X	X			
Himalayan tahr[d]	Hemitragus jemlahicus						
Nilgiri tahr[d]	Hemitragus hylocrius						
Arabain tahr[d]	Hemitragus jayakeri						
Perissodactyla							
Feral horse[c]	Equus caballus	X	X	X	X		

[a]Nomenclature follows Burt and Grossenheider (1976).

[b]G/DS = Grassland-desert shrub
PJ = Pinyon-juniper
PP = Ponderosa pine
MC = Mixed conifer
A = Alpine
R = Riparian
XX = Preferred habitat

[c]Nomenclature follows Findley et al. (1975).

[d]Nomenclature follows Schaller (1977).

Table A2. Avifauna of the San Juan Basin Regional Uranium Study Area.

Order-common name	Scientific name	Habitat[a]	Season[b]	Abundance	Frequency	Remarks
Gavilformes						
Common loon	Gavia immer	R	WR,M	R	C-O	
Podicipediformes						
Horned grebe	Podiceps auritus	R	YR,SM	R-C	C-O	
Eared grebe	Podiceps nigricollis	R	YR,SR	R-C	C-O	Breeds
Western grebe	Aechmophorus occidentalis	R	WR	R-F	C-O	
Pied-billed grebe	Podilymbus podiceps	R	SR,WR,M	R-F	C-O	Breeds
Pelecaniformes						
White-pelican	Pelecanus erythrorhynchos	R	M	R-U	C	Colo. endangered
Double-crested cormorant	Phalacrocorax auritus	R	M	R-U	C	
Ciconiiformes						
Great blue heron	Ardea herodias	R	YR,SR	U-F	C-O	Breeds
Green heron	Butorides striatus	R	YR,WR	R-U	C-O	May breed
Cattle egret	Bubuicus ibis	R	SR,W,M	R	C	
Great egret	Casmerodius albus	R	M	R-F	C	
Snowy egret	Egretta thula	R	M	R-F	C	
Black-crowned night heron	Nycticorax nycticorax	R	SR	R-U	C	May breed
Least Bittern	Ixobrychus exills	R	SR	R-U	C	May breed
American bittern	Botaurus lentiginosus	R	SR,WR,M	R-U	C-O	Breeds
White-faced ibis	Plegadis chihi	R	SR,M	R-F	C	
Anseriformes						
Whistling swan	Cygnus columbianus	R	WR,M	R-U	C	
Canada goose	Branta canadensis	R	YR,M	R-F	C-1	Breeds
White-fronted goose	Anser albifrons	R	WR,M	R-U	C-O	
Snow goose	Chen caerulescens	R	WR	R	C-O	

Table A2. (Continued)

Order-common name	Scientific name	Habitat[a]	Season[b]	Abundance	Frequency	Remarks
Mallard	Anas platyrhynchos	R	YR	R-A	I-R	Breeds
Gadwall	Anas strepera	R	YR,SR,WR,M	U-F	C-O	
Pintail	Anas acuta	R	YR,SR,M	R-F	C-O	Breeds
Green-winged teal	Anas crecca	R	WR,M	R-A	C	
Blue-winged teal	Anas discors	R	YR,SR,M	R-C	O	May breed
Cinnamon teal	Anas cyanoptera	R	SR,WR	U-C	CI	Breeds
American wigeon	Anas americana	R	WR,M	R-U	C-O	
Northern shoveler	Anas clypeata	R	YR,WR,M	R-C	R	May breed
Wood duck	Aix sponsa	R	WR,M	R-U	C	
Redhead	Aythya americana	R	SR,WR,M	R-F	C-O	May breed
Ring-necked duck	Aythya collaris	R	WR,M	R-F	C	
Canvasback	Aythya valisineria	R	WR,M	R-F	O	
Lesser scaup	Ahthya affinis	R	WR,M	R-U	C-O	
Common goldeneye	Bucephala clangula	R	SR,WR,M	R-F	C	
Barrow goldeneye	Bucephala islandica	R	WR	R	X	
Bufflehead	Bucephala albeola	R	WR,M	R-F	C	
Surf scoter	Melanitta perspicillata	R	M	R	X	
Ruddy duck	Oxyura jamaicensis	R	SR,WR,M	R-C	O	Breeds
Hooded merganser	Mergus cucullatus	R	WR	R	C-I	
Common merganser	Mergus merganser	R	YR	R-U	O	Breeds
Red-breasted merganser	Mergus serrator	R	M	R-U	C-O	
Falconiformes						
Turkey vulture	Cathartes aura	G/DS,R,PJ,PP,MC	SR	U-C	C-I	Breeds
Mississippi kite	Ictinia mississippiensis	R	M	R	X	Endangered
Goshawk	Accipiter gentillis	A-PJ,PP,MC	SR,WR,M	R-U	I	
Sharp-shinned hawk	Accipter striatus	G/DS,R	YR	R-F	I	Breeds
Cooper hawk	Accipiter cooperii	PJ,PP,MC,R	YR	R-F	I	
Red-tailed hawk	Buteo jamaicensis	G/DS,PJ,PP,MC	YR	R-U	O-I	Breeds
Swainson hawk	Buteo swainsoni	G/DS,R	SR	U-F	C-O	Breeds
Zone-tailed hawk	Buteo albonotatus	PJ,PP,R	SR,M	R-U	C	Breeds, endangered

Table A2. (Continued)

Order-common name	Scientific name	Habitat[a]	Season[b]	Abundance	Frequency	Remarks
Rough-legged hawk	Buteo lagopus	G/DS	WR,M	R-C	I	
Ferruginous hawk	Buteo regalis	G/DS,PJ	WR,M	R-F	C-O	May breed
Golden eagle	Aquila chrysaetos	G/DS,PJ	YR	R-U	I	Breeds
Bald eagle	Haliaeetus leucocephalus	R	WR,M	R	C	Endangered
Marsh hawk	Circus cyaneus	PJ,PP,MC,G/DS,R	SR,WR,M	R-F	O	Breeds
Osprey	Pandion haliaetus	R	M	R	O	Endangered
Prairie falcon	Falco mexicanus	PP,MC,G/DS,PJ	YR	R-U	C-O	Breeds
Peregrine falcon	Falco peregrinus	MC,G/DS,R,PJ	YR	R	C-O	Endangered
Merlin	Falco columbarius	PJ,PP	WR,M	R	C	
American kestrel	Falco sparverius	G/DS,R,PJ,PP,MC	YR	F	O-R	Breeds
Galliformes						
Blue grouse	Dendragopus obscurus	A,PP,MC	R	U-C	O-R	Breeds
White-tailed ptarmigan	Lagopus leucurus	A,MC	R	R	X	
Sharp-tailed grouse	Pedioecetes phasianellus	PJ,PP,MC	R	U-C	O-R	Breeds
Sage grouse	Centrocercus urophasianus	G/DS	R	R-U	O-R	Endangered, NM
Scaled quail	Callipepia squamata	G/DS,R	YR	U-C	O-R	Breeds
Gambel quail	Lophortyx gambelii	G/DS,R	YR	U-C	O-R	Breeds
Ring-necked pheasant	Phasianus colchicus	G/DS,R	YR	R-F	O-R	Breeds-introduced
Chukar	Alectoris chukar	G/DS	YR	R-U	C	Breeds-introduced
Wild turkey	Meleagris gallopavo	PJ,R,PP,MC	YR	R-C	O-R	Breeds
Gruiformes						
Whooping crane	Crus americana	R	M	R		Possible migrant
Sandhill crane	Grus canadensis	R	M	R		Possible migrant
Common crane	Grus grus	R	M	R	X	Straggler
Virginia rail	Rallus limicola	R	SR	R-U	U-I	Breeds
Sora	Porzana carolina	R	SR	R-F	O-I	Breeds
Common gallinule	Gallinula chloropus	R	SR,M	R-C	O-I	Breeds
American coot	Fulica americana	R	YR	F-C	C-R	Breeds

Table A2. (Continued)

Order-common name	Scientific name	Habitat[a]	Season[b]	Abundance	Frequency	Remarks
Charadriiformes						
Semi-palmated plover	Charadrius semipalmatus	R	M	R	I	
Snowy plover	Charadrius alexandrinus	R	M	R-F	C	
Killdeer	Charadrius vociferus	R,G/DS,PJ	YR,SR	R-C	I-R	Breeds
Mountain plover	Charadrius montanus	G/DS,R	SR,M	R-F	C-O	Breeds
American golden plover	Pluvialis dominica	R	M	R	X	
Black-bellied plover	Pluvialis squatarola	G/DS,R	M	R-U	C	
Common snipe	Capella gallinago	R	WR,M	R-F	C-O	
Long-billed curlew	Numenius americanus	R	M	R-F	C	
Upland sandpiper	Bartramia longicauda	G/DS,R	M	R-F	C	
Spotted sandpiper	Actitis macularia	PP,R	SR,UR,M	R-F	C-1	Breeds
Solitary sandpiper	Tringa solitaria	R	M	R-F	C	
Greater yellowlegs	Tringa melanoleuca	R	M	R	C	
Lesser yellowlegs	Tringa flavipes	R	M	R	C-O	
Willet	Catoptrophorus semipalmatus	R	M	R-F	C	
Pectoral sandpiper	Calidris melanotos	G/DS,R	M	R-U	C-O	
Baird sandpiper	Calidris bairdii	R	M	R-F	O-R	
Least sandpiper	Calidris minutilla	R	M	R-U	C-O	
Western sandpiper	Calidris mauri	R	M	R-UqC		
Sanderling	Calidris albus	R	M	R-U	C	
Long-billed bowitcher	Limodromus scolopaceus	R	M	R-F	C	
Marbled godwit	Limosa fedoa	R	M	R-U	C-O	
American avocet	Recurvirostra americana	R	M,SR	R-F	C-O	Breeds
Black-necked stilt	Himantopus mexicanus	R	M	R-F	O	
Wilson phalarope	Steganopus tricolor	R	M	R-C	O	
Northern phalarope	Lobipes lobatus	R	M	R-F	C-I	
Herring gull	Larus argentatus	R	M	R-U	C	
California gull	Larus californicus	R	M	R	X	
Ring-billed gull	Larus delawarensis	R	M,WR	R-U	C-O	
Laughing gull	Larus atricilla	R	M	R	X	

Table A2. (Continued)

Order-common name	Scientific name	Habitat[a]	Season[b]	Abundance	Frequency	Remarks
Franklin gull	Larus pipixcan	R	M	R-U	C-I	
Bonaparte gull	Larus philadelphia	R	M	R-U	C-I	
Sabine gull	Xema sabini	R	M	R	X	
Forster tern	Sterna forsteri	R	M	R-F	C-O	
Common tern	Sterna hirundo	R	M	R	X	
Caspian tern	Sterna caspia	R	M	R	X	
Black tern	Chlidonias niger	R	M,SR	R-C	C-O	
Columbiformes						
Band-tailed pigeon	Columba fasciata	PJ,PP,MC,R	SR	R-C	I	Breeds
Rock dove	Columba livia	G/DS,R	YR	R-U	O-R	Breeds
Mourning dove	Zenaida macroura	G/DS,R,PJ,PP,MC,A	YR,SR	F-A	I-R	Breeds
Inca dove	Scardafella inca	R	WR,M	R	X	
Cuculiformes						
Yellow-billed cuckoo	Coccyzus americanus	R	SR	R-U	I	Breeds
Roadrunner	Geococcyx californianus	G/DS,PJ,R	YR	R	C	Breeds
Strigiformes						
Barn owl	Tyto alba	G/DS,R	SR,WR	R	C	Breeds
Screech owl	Otus asio	PJ,R,PP,MC	YR,SR,WR	R	C	Breeds
Flammulated owl	Otus flammeolus	PJ,PP,MC	SR	R-U	C	Breeds
Great horned owl	Bubo virginianus	R,PJ,PP,MC	YR,SR	R-F	C-I	Breeds
Pygmy owl	Glaucidium gnoma	PJ,PP	M	R	C	Breeds
Burrowing owl	Athene cunicularia	G/DS,PJ	SR	R-F	C-I	Breeds
Spotted owl	Strix occidentalis	PJ,PP,MC,R	SR,M	R-F	C-I	Breeds
Long-eared owl	Asio otus	G/DS,PJ,PP,MC	SR	R-U	C	Breeds
Short-eared owl	Asio flammeus	G/DS,R	WR,M	R-F	C	Breeds
Saw-whet owl	Aegolius acadicus	PP,MC,R	SR	R	C	Breeds

Table A2. (Continued)

Order-common name	Scientific name	Habitat[a]	Season[b]	Abundance	Frequency	Remarks
Caprimulgiformes						
Poor-will	Phalaenoptilus nuttallii	G/DS,R,PJ	SR	R-F	C-O	Breeds
Common nighthawk	Chordeiles minor	G/DS,R,PJ,PP	SR	F-C	I-R	Breeds
Apodiformes						
Black swift	Cypseloides niger	R,G/DS,PJ,PP,MC,A	SR,M	R	C-O	
White-throated swift	Aeronautes saxatalis	R,G/DS,PJ,PP,MC,A	SR,M	R-F	C-I	Breeds
Black-chinned hummingbird	Archilochus alexandri	G/DS,R,PJ,PP	SR	R-F	C-O	Breeds
Broad-tailed hummingbird	Selasphorus platycercus	PJ,PP,R,G/DS	SR,M	U-C	O	May breed
Rufous hummingbird	Selasphorus rufus	G/DS,R,PJ,PP	M	R-C	C-O	
Calliope hummingbird	Stellula calliope	PP	M	R	X	
Rivoli hummingbird	Eugenes fulgens	R,PP	S	R-U	C-O	
Coraciiformes						
Belted kingfisher	Megaceryle alcyon	R	SR,WR	U-F	O-R	Breeds
Piciformes						
Common flicker	Colaptes auratus	R,PJ,PP,MC	YR	F-C	I-R	Breeds
Red-headed woodpecker	Melanerpes erythrocephalus	R	SR	R-U	O	Endangered breeds
Acorn woodpecker	Melanerpes formicivorus	PP,R,PJ	WR,M	R-C	C-O	
Lewis woodpecker	Melanerpes lewis	PJ,PP,R	YR,SR	R-C	O-I	Breeds
Yellow-bellied sapsucker	Sphyrapicus varius	PJ,PP,R,MC	SR,M	R-F	O-I	Breeds
Williamson sapsucker	Sphyrapicus varius	PJ,PP,MC	YR,SR,WR	R-F	O-I	
Hairy woodpecker	Picoides villosus	PJ,PP,R,MC	YR	R-C	C-O	Breeds
Downy woodpecker	Picoides pubescens	PJ,PP,R,MC	YR,SR	R-F	C-O	May breed

Table A2. (Continued)

Order-common name	Scientific name	Habitat[a]	Season[b]	Abundance	Frequency	Remarks
Ladder-backed woodpecker	Picoides scalaris	G/DS,PJ,PP,MC	YR,SM	R-F	O	
Northern three-toed woodpecker	Picoides tridactylus	PP,MC	SR	R-U	C-O	Breeds
Passeriformes						
Eastern kingbird	Tyrannus tyrannus	R,G/DS	SR	U-F	O-I	Breeds
Western kingbird	Tyrannus verticalis	G/DS,PJ	SR	U-F	C-R	Breeds
Cassin kingbird	Tyrannus vociferans	PJ,PP,R	SR	U-C	O-R	Breeds
Ash-throated flycatcher	Myiarchus cinerascens	G/DS,PJ,PP	SR	F	O-R	Breeds
Eastern phoebe	Sayornis phoebe	R	M	R	C	
Black phoebe	Sayornis saya	G/DS	YR,SR	F	O	Breeds
Willow flycatcher	Empidonax traillii	PP,R	SR,M	R-F	C-O	
Hammond flycatcher	Empidonax hammondii	PP	SR,M	R	C-O	
Dusky flycatcher	Empidonax oberholseri	PP	SR,M	R-U	C	
Gray flycatcher	Empidonax wrightii	G/DS,PJ	R	R-F	C-O	Breeds
Western flycatcher	Empidonax difficilis	PJ,PP,R,MC	SR,M	U-F	C	
Buff-breasted flycatcher	Empidonax fulvifrons	PP,PJ	SR	R	X	Endangered
Coues flycatcher	Contopus pertinax	PJ,PP,MC	SR	R	C	
Western wood pewee	Contopus sordidulus	PJ,PP,R,MC	SR,M	U-F	C-R	Breeds
Olive-sided flycatcher	Nuttallornis borealis	R,PP,MC	SR,M	R-F	O-I	Breeds
Horned lark	Eremophila alpestris	G/DS,A	YR	C-A	R	Breeds
Violet-green swallow	Tachycineta thalassina	PP,MC	SR	U-C	C-R	
Tree swallow	Tridoprocne bicolor	PJ,R,PP	SR,M	R-U	I	
Bank swallow	Riparia riparia	G/DS,R	SR,M	R-F	C-O	
Rough-winged swallow	Stelgidopteryx ruficollis	R	SR	C	I-R	Breeds
Barn swallow	Hirundo rustica	G/DS	SR	C-A	O-R	Breeds
Cliff swallow	Petrochelidon pyrrhonota	G/DS	SR	C-A	O-R	Breeds
Purple martin	Progne subis	PP,MC	SR,M	R-U	C	Breeds

Table A2. (Continued)

Order-common name	Scientific name	Habitat[a]	Season[b]	Abundance	Frequency	Remarks
Gray jay	Perisoreus canadensis	PP,MC	YR	R	C	
Blue jay	Cyanocitta cristata	PJ,R	M,WR	R-U	X	
Steller jay	Cyanocitta stelleri	PJ,PP,MC	SR,WR	U-C	I	May breed
Scrub jay	Aphelocoma coerulescens	G/DS,PJ	YR	U-F	C-I	Breeds
Black-billed magpie	Pica pica	G/DS,R,PJ,PP	YR	R-C	I-R	
Common raven	Corvus corax	G/DS,PJ,PP,R	YR,SR	U-F	C-R	Breeds
Common crow	Corvus brachyrhynchos	G/DS,R,PJ,PP	YR,WR	R-F	C-I	
Pinyon jay	Gymnorhinus cyanocephalus	PJ	YR,WR	R-F	C-I	Breeds
Clark nutcracker	Nucifraga columbiana	PJ,PP,MC	YR,WR,M	R-C	I-R	Breeds
Black-capped chickadee	Parus atricapillus	PJ,R,PP,MC	YR,W	F	C-I	Breeds
Mountain chickadee	Parus gambeli	PJ,PP,R	YR,WR	U-C	I-R	Breeds
Plain titmouse	Parus inornatus	PJ	YR,SR,WR	U-F	C-I	Breeds
Bushtit	Psaltriparus minimus	PJ,R,PP	YR,M	U	I	Breeds
White-breasted nuthatch	Sitta carolinensis	PJ,R,PP,MC	YR,SR	U	C-O	Breeds
Red-breasted nuthatch	Sitta canadensis	PJ,R,PP	YR,WR,M	R-U	C-O	Breeds
Pigmy nuthatch	Sitta pygmaea	PJ,R,PP,MC	YR,WR	U-C	C-I	Breeds
Brown creeper	Certhia familiaris	PJ,PP,MC	YR,SR,WR	R-F	O-I	Breeds
Dipper	Cinclus mexicanus	R,PJ,PP,MC	YR,WR	R-F	O-I	
House Wren	Troglodytes aedon	PJ,R,PP,MC	SR	U-C	I-R	Breeds
Winter wren	Troglodytes troglodytes	MC	W,M	U	O-I	
Bewick wren	Thryomanes bewickii	PJ,R,PP	YR,SR	R-U	O-I	Breeds
Long-billed marsh wren	Cistothorus palustris	R	SR,WR,M	R-F	I-R	Breeds
Canyon wren	Catherpes mexicanus	G/DS,PJ,PP	YR,SR,M	U-C	O-R	Breeds
Rock wren	Salpinctes obsoletus	G/DS,PJ,PP,A	YR,SR	U-C	O-R	Breeds
Northern mockingbird	Mimus polyglottos	G/DS,PJ,PP	YR,SR,WR	U-C	C-R	Breeds
Gray catbird	Dumetella carolinensis	G/DS,R	M	R-U	C-I	May breed

Table A2. (Continued)

Order-common name	Scientific name	Habitat[a]	Season[b]	Abundance	Frequency	Remarks
Brown thrasher	Toxostoma rufum	G/DS	WR,M	R	C-I	
Bendire thrasher	Toxostoma bendirei	G/DS,PJ	SR	R-U	C-I	Breeds
Sage thrasher	Oreoscoptes montanus	G/DS	YR,SR,WR	U-F	C-O	Breeds
American robin	Turdus migratorius	PJ,R,PP,MC,A	YR	C	O-R	Breeds
Hermit thrush	Catharus guttatus	PP,R,MC	YR,SR,WR	R-U	C-I	Breeds
Swainson thrush	Catharus ustulatus	PJ,PP,R	SR	R-U	C-O	
Eastern bluebird	Sialia sialis	PJ,R	WR,M	R-U	C-O	
Western bluebird	Sialia mexicana	PJ,R,PP,MC	YR,SR	U-C	I-R	Breeds
Mountain bluebird	Sialia currucoides	PJ,PP,MC,A	YR	R-C	I-R	Breeds
Townsend solitaire	Myadestes townsendi	PJ,PP	YR,SR,WR	R-F	I-R	Breeds
Blue-gray gnatcatcher	Polioptila caerulea	G/DS,PJ,R	SR,M	R-C	O-I	Breeds
Golden-crowned kinglet	Regulus satrapa	PP,MC	WR,M	R-U	C-I	
Ruby-crowned kinglet	Regulus calendula	PJ,PP,MC	WR,M	R-F	C-I	
Water pipit	Anthus spinoletta	PJ,PP,R,MC,A	WR,M	R-U	C-O	
Bohemian waxwing	Bombycilla garrulus	C/DS,PJ	WR,M	R-C	C-O	
Cedar waxwing	Bombycilla cedrorum	G/DS,PJ	WR,M	U-CqO-I		
Northern shrike	Lanius excubitor	G/DS,PJ	WR,M	R	C-O	
Loggerhead shrike	Lanius ludovicianus	G/DS,PJ	YR,SR	U-C	I-R	Breeds
Starling	Sturnus vulgaris	PJ,R,MC	YR	F-C-A	O-R	Breeds-introduced
Hutton vireo	Vireo huttoni	R,PJ	WR	U	O	
Gray vireo	Vireo vicinior	PJ	SR,M	U-F	C-I	Breeds
Solitary vireo	Vireo solitarius	PJ,PP,R	SR	U-C	C-I	Breeds
Red-eyed vireo	Vireo olivaceous	PJ,MC	M	R	X	
Warbling vireo	Vireo gilvus	PJ,PP,R,MC	SR	R-C	C-O	Breeds
Black and white warbler	Mniotilta varia	PJ	M	R	C-O	
Orange-crowned warbler	Vermivora celata	PP,MC	SR,M	R-U	C-O	
Nashville warbler	Vermivora ruficapilla	PJ	M	R	X	

Table A2. (Continued)

Order-common name	Scientific name	Habitat[a]	Season[b]	Abundance	Frequency	Remarks
Virginia warbler	Vermivora virginiae	R,PJ,PP	SR,M	U-F	O	Breeds
Lucy warbler	Vermivora luciae	R,G/DS	M	R	C	
Yellow warbler	Dendroica petechia	R,PJ,PP	SR,M	R-C	O-I	Breeds
Magnolia warbler	Dendroica magnolia	PP	M	R	X	
Black-throated blue warbler	Dendoica caerulescens	PJ	M	R	X	
Yellow-rumped warbler	Dendroica coronata	PJ,PP	YR,SR	U-C	O-R	Breeds
Black-throated gray warbler	Dendroica nigrescens	PP,MC	SR,M	U	O	Breeds
Townsend warbler	Dendroica townsendi	R,PJ,PP	M	R-U	C-O	
Black-throated green warbler	Dendroica virens	PP	M	R	X	
Hermit warbler	Dendroica occidentalis	PJ,PP	M	R-U	C	
Yellow-throated warbler	Dendroica dominica	R,PJ	M	R-U	C	
Grace warbler	Dendroica graciae	PJ,PP	SR,M	R-F	C-I	Breeds
Chestnut-sided warbler	Dendroica pennsylvanica	R,PJ	M	R	C	
Bay-breasted warbler	Dendroica castanea	R,PJ	YR	R	C	
Palm warbler	Dendroica palmarum	PJ	M	R	X	
Ovenbird	Seiurus aurocapillus	PJ	M	R	X	
Northern waterthrush	Seiurus noveboracensis	R	M	R	C-O	
MacGillivray warbler	Oporornis tolmiei	R,PP,MC	M,SR	R-F	C-I	
Common yellowthroat	Geothlypis trichas	R	SR,M	R-C	I	Breeds
Yellow-breasted chat	Icteria virens	R,G/DS	SR	U-C	O-R	Breeds
Red-faced warbler	Cardellina rubrifrons	PP,MC,R	SR	U	C	
Hooded warbler	Wilsonia citrina	R,PJ,PP	M	U-F	C	
Wilson warbler	Wilsonia pusilla	R,G/DS	M	R-F	I-R	
American redstart	Setophaga ruticilla	PJ	M	R-U	C-I	
Painted redstart	Myroborus pictus	PJ,R	SR	R-F	C	

Table A2. (Continued)

Order-common name	Scientific name	Habitat[a]	Season[b]	Abundance	Frequency	Remarks
House sparrow	Passer domesticus	G/DS,PJ	YR	U-C	R	Breeds-introduced
Bobolink	Dolichonyx oryzivorus	R	S,M	U-C	O	
Eastern meadowlark	Sturnella magna	G/DS,R	SR	R-U	C-I	
Western meadowlark	Sturnella neglecta	G/DS,R	SR	U-C	O-R	Breeds
Yellow-headed blackbird	Xanthocephalus xanthocephalus	R	SR,WR	F-C-A	C-R	Breeds
Red-winged blackbird	Agelaius phoeniceus	R,PJ,PP	YR,SR	C-A	R	Breeds
Hooded oriole	Icterus cucullatus	P,PJ	SR	U	C	
Scott oriole	Icterus parisorum	G/DS,PJ	SR	U-F	O-I	Breeds
Northern oriole	Icterus galbula	R	SR	U-C	O-R	Breeds
Brewer blackbird	Euphagus cyanocephalus	G/DS,R	SR	U-F	C-R	Breeds
Great-tailed grackle	Quiscalus mexicanus	R	SR,WR	U-C	C-O	Breeds
Brown-headed cowbird	Molothrus ater	R,PJ,PP,MC	SR,WR	F-C	O-R	Breeds
Western tanager	Piranga ludoviciana	R,PJ,PP,MC	SR,M	R-F	C-O	Breeds
Scarlet tanager	Piranga olivacea	R,PJ,PP	SR,M	R-U	C-O	
Hepatic tanager	Piranaga flava	PP,PJ,MC,RqSR,M	R-U	C-O		
Rose-breasted grosbeak	Pheucticus ludovicianus	PJ	M	R-U	C-I	
Black-headed grosbeak	Pheucticus melanocephalus	R,PJ,PP,MC	SR	U-F	O-R	Breeds
Blue grosbeak	Guiraca caerulea	G/DS,R	SR	U-F	O-R	Breeds
Indigo bunting	Passerina cyanea	R,G/DS	SR	R-F	C-O	Breeds
Lazuli bunting	Passerina amoena	R,G/DS	SR	E-F	O-I	Breeds
Dickcissel	Spiza americana	G/DS	M	R	X	
Evening grosbeak	Hesperiphona vespertina	PJ,PP,MC	YR,WR,SR	R-F	C-R	
Purple finch	Carpodacus purpureus	PJ,MC	M	U	X	
Cassin finch	Carpodacus cassinii	PJ,PP,MC,A	YR,WR,M	R-U	C-I	
House finch	Carpodacus mexicanus	G/DS,PJ,PP	YR,SR	U-C	I-R	Breeds
Pine grosbeak	Pinicola enucleator	MC	YR	R-F	I-R	May breed
Gray-crowned rosy finch	Leucosticte tephrocotis	PJ,PP,R	M	R-C	O-I	

Table A2. (Continued)

Order-common name	Scientific name	Habitat[a]	Season[b]	Abundance	Frequency	Remarks
Black rosy finch	Leucosticte atrata	PJ,PP,R,MC,A	M	R-U	C-O	
Brown-capped rosy finch	Leucosticte australis	R	M	R-U	C-O	
Pine siskin	Carduelis pinus	R,PP,MC,A	SR,WR	R-U	C-I	Breeds
American goldfinch	Carduelis americana	G/DS,MC,PJ,R	SR,WR	R	C-O	Breeds
Lesser goldfinch	Carduelis psaltria	R	SR,WR	R-F	C-I	Breeds
Lawrence goldfinch	Carduelis lawrencei	R	SR,WR	R	X	
Red crossbill	Loxia curvirostra	PP	M	R-C	I	Breeds
White-winged crossbill	Loxia leucoptera	PP	M	R	C	
Green-tailed towhee	Pipilo chlorurus	G/DS,R	SR	R-C	I-R	
Rufous-sided towhee	Pipilo erythrophthalmus	R,G/DS,PJ,PP,MC	SR,WR	R-C	I-R	Breeds
Brown towhee	Pipilo fuscus	G/DS,PJ,PP,R	SR,WR	U	O-I	Breeds
Lark bunting	Calamospiza melanocorys	G/DS	M	R	C	
Savannah sparrow	Passerculus sandwichensis	G/DS	M	R-U	C	
Baird sparrow	Ammodramus bairdii	G/DS	SR,M	R-C	I-R	Breeds
Vesper sparrow	Pooecetes gramineus	G/DS	SR,M	R-C	I-R	Breeds
Lark sparrow	Chondestes grammacus	G/DS,PJ	SR,M	U-C	C-R	Breeds
Rufus-crowned sparrow	Aimophila ruficeps	G/DS,PJ	M	R	X	
Cassin sparrow	Aimophila cassinii	G/DS	M,SR	R	C	
Black-throated sparrow	Amphipiza billineata	G/DS	SR	C	I-R	Breeds
Sage sparrow	Amphispiza belli	G/DS	SR,WR	R-F	C-O	Breeds
Dark-eyed junco	Junco hyemalis	PJ,PP,R	WR	U-A	I-R	
Gray-headed junco	Junco caniceps	PJ,PP,MC	YR	U-C	O-R	Breeds
Tree sparrow	Spizella arborea	G/DS,R	WR	R-E	O-I	
Chipping sparrow	Spizella passerina	PJ,R,PP,MC	SR	F-C	C-R	Breeds
Brewer sparrow	Spizella breweri	G/DS	SR	U-C	I-R	Breeds
Black-chinned sparrow	Spizella atrogularis	G/DS,PJ	SR	R-F	I-R	

Table A2. (Concluded)

Order-common name	Scientific name	Habitat[a]	Season[b]	Abundance	Frequency	Remarks
Harris sparrow	Zonotrichia querula	G/DS	WR,M	R-U	C-I	
White-crowned sparrow	Zonotrichia leucophrys	G/DS,R,PJ	WR	U-C-A	I-R	
Golden-crowned sparrow	Zonotrichia atricapilla	G/DS,PJ	W,M		I	
White-throated sparrow	Zonotrichia albicollis	A,G/DS	M	R-U	C-I	
Fox sparrow	Passerella iliaca	G/DS,R	M	R	X	
Lincoln sparrow	Melospiza lincolnii	A,G/DS,R,MC	W	R-F	C	
Swamp sparrow	Melospiza georgiana		W	R	C	
Song sparrow	Melospiza melodia	R,MC	WR	R-U	C-I	
Lapland longspur	Calcarius lapponicus	G/DS	M	R	X	

[a] R = Riparian
G/DS = Grassland-Desert Shrub
PJ = Pinyon-Juniper Woodland
PP = Ponderosa Pine Forest
MC = Mixed Conifer Forests
A = Alpine

[b] YR = Year-long Resident
SR = Summer Resident
WR = Winter Resident
M = Migrant

[c] R = Rare
U = Uncommon
F = Fairly Common
C = Common
A = Abundant

[d] X = Accidental
C = Casual
O = Occasional
I = Irregular
R = Regular

Table A3. Herptofauna and habitat preferences with the San Juan Basin Regional Uranium Study Area.

Common Name	Scientific name	R	G/DS	PJ	PP	MC	A
Tiger salamander[a]	Ambystoma tigrinum	X	X	X	X	X	
Jemez mountains salamander	Plethodon neomexicanus					X	
Boreal toad	Bufo boreas	X	X	X	X	X	
Great plains toad	Bufo cognatus		X				
Red-spotted toad	Bufo punctatus	X	X				
Woodhouse's toad	Bufo woodhousei	X	X	X	X	X	
Canyon treefrog	Hyla arenicolor	X	X	X	X		
Mountain treefrog	Hyla eximia						
Western chorus frog	Pseudacris triseriata	X				X	
Bullfrog	Rana catesbeiana	X					
Northern leopard frog	Rana pipiens	X	X	X	X	X	X
Couch's spadefoot	Scaphiopus couchi		X				
Plains spadefoot	Spea bombifrons	X					
Western spadefoot	Spea hammondi	X	X				
Painted turtle	Chrysemys picta	X					
Western box turtle	Terrapene ornata						
Lesser earless lizard	Callisaurus macolata		X				
Chihuahua whiptail	Cnemidophorus exanguis	X	X	X	X		
Plateau whiptail	Cnemidophorus velox	X		X	X		
Western whiptail	Cnemidophorus tigris						
Little striped whiptail	Cnemidophorus inornatus		X	X			
Collared lizard	Crotaphytus collaris	X	X	X			
Leopard lizard	Crotaphytus wislizeni		X				
Many-lined skink	Eumeces multivirgatus	X	X	X	X		
Great plains skink	Eumeces obsoletus	X	X	X	X		
Short-horned lizard	Phrynosoma douglassi		X	X	X	X	
Sagebrush lizard	Sceloporus graciosus	X	X	X	X	X	
Desert spiny lizard	Sceloporus magister	X	X	X			
Eastern fence lizard	Sceloporus undulatus	X	X	X	X	X	
Rock lizard	Urosarus ornatus	X	X	X	X		
Side-blotched lizard	Uta stansburiana	X	X	X			
Glossy snake	Arizona elegans		X	X			
Coachwhip snake	Masticophis flagellum		X	X			
Striped whipsnake	Masticophis taeniatus	X	X	X	X		
Western diamondback rattlesnake	Crotalus atrox		X	X	X		
Blacktail rattlesnake	Crotalus molossus	X	X	X	X		
Prairie rattlesnake	Crotalus viridis	X	X	X	X	X	
Ring-necked snake	Diadophis punctatus	X			X	X	
Bull snake	Pituophis melanoleucus		X	X	X	X	
Night snake	Hypsiglena torquata		X	X			
Common kingsnake	Lampropeltis getalus	X	X	X	X	X	
Milk snake	Lampropeltis triangulum	X	X	X	X	X	
Smooth greensnake	Opheodrys vernalis	X				X	
Longnose snake	Rhinocheilus lecontei		X				
Mountain patchnose snake	Salvadora grahamiae			X	X		

Table A3. (Concluded)

Common Name	Scientific name	R	G/DS	PJ	PP	MC	A
Plains blackheaded snake	Tantilla nigriceps		X	X	X	X	
Black-necked garter snake	Thamnophis cyrtopsis	X	X	X	X	X	
Wandering Garter snake	Thamnophis elegans						

[a]Nomenclature follows Applegarth (1978).

Table A4. Fishes found within the San Juan Basin Regional Uranium Study Area.

Common name	Scientific name	Status
Coho salmon[a]	Oncorhynchus kisutch	Introduced
Kokanee	Oncorhynchus nerka	Introduced
Cutthroat trout	Salmo clarki	Introduced and Native
Rainbow trout	Salmo gairdneri	Introduced
Brown trout	Salmo trutta	Introduced
Brook trout	Salvelinus fontinalis	Introduced
Northern pike	Esox lucius	Introduced
Longfin dace	Agosia chrysogaster	Introduced
Goldfish	Carassius auratus	Introduced
Lake chub	Couesius plumbeus	Introduced
Carp	Cyprinus carpio	Introduced
Bonytail chub	Gila elegans	Native[b]
Rio Grande chub[c]	Gila pandora	Native[d]
Roundtail chub	Gila robusta	Native[b]
Brassy minnow	Hybognathus hankinsoni	Native[d]
Flathead chub	Hybopsis gracilis	Native[d]
Golden shiner	Notemigonus crysoleucas	Introduced
Red shiner	Notropis lutrensis	Native[d]
Fathead minnow	Pimephales promelas	Native[d]
Colorado squawfish	Ptychocheilus lucius	Native[b]
Longnose dace	Rhinichthys cataractae	Native[d]
Speckled dace	Rhinichthys osculus	Native[b]
Redside shiner	Richardsonius batteatus	Introduced
Longnose sucker	Catostomus catostomus	Introduced
White sucker	Catostomus commersoni	Introduced
Bluehead sucker	Catostomus discobolus	Native[b]
Zuni mountain sucker	Catostomus (Pantosteus) discobolus yarrowi	Native[b]
Flannelmouth sucker	Catostomus latipinnis	Native[b]
Rio grande sucker	Catostomus plebius	Native[b]
Humpback sucker	Xyrauchen texanus	Native[b]
Black bullhead	Ictalurus melas	Introduced
Yellow bullhead	Ictalurus nebulosus	Introduced
Brown bullhead	Ictalurus natalis	Introduced
Channel catfish	Ictalurus punctatus	Introduced
Plains killifish	Fundulus kansae	Introduced
Rio grande killifish	Fundulus zebrinus	Introduced
Mosquitofish	Gambusia affinis	Introduced
Green sunfish	Lepomis cyanellus	Introduced
Pumpkinseed	Lepomis gibbosus	Introduced
Orange-spotted sunfish	Lepomis humilis	Introduced
Bluegill	Lepomis macrochirus	Introduced
Smallmouth bass	Micropterus dolomieui	Introduced
Largemouth bass	Micropterus salmoides	Introduced
White crappie	Pomoxis annularis	Introduced
Black crappie	Pomoxis nigromaculatus	Introduced

Table A4. (Concluded)

Common name	Scientific name	Status
Iowa darter	Etheostoma exile	Introduced
Johnny darter	Etheostoma nigrum	Introduced
Yellow perch	Perca flavescens	Introduced
Mottled sculpin	Cottus bairdi	Native[b]
Piute sculpin	Cottus beldingi	Introduced

[a]Unless stated otherwise, nomenclature follows Bailey et al. (1970).

[b]Native west of Continental Divide only.

[c]Listed as Gila nigrescens in Bailey et al. (1970). It will be Gila pandora in their next edition (Dr. Paul Turner, Dept. Fishery and Wildlife Sciences, New Mexico State University, Las Cruces, personal communication.)

[d]Native east of Continental Divide only.

Table A5. Occurrence of fishes by species in bodies of water on the San Juan Basin Regional Uranium Study Area.

Body of water	Species of fish
Paguate Creek (Laguna Pueblo)	Rainbox x cutthroat trout hybrid
Paguate Lake (Laguna Pueblo)	Rainbow trout Fathead minnow Channel catfish Green sunfish
Rio San Jose (Laguna & Acoma Pueblos)	Rio Grande chub Fathead minnow White sucker Rio grande sucker Black bullhead Channel catfish Mosquitofish
Acomita Lake (Acoma Pueblo)	Rainbow trout Brown trout Rio grande chub Fathead minnow Channel catfish
Mariano Lake (Navajo Reservation)	Rainbow trout
Mulholland Lake (Navajo Reservation)	Rainbow trout Channel catfish
Chuska Lakes (Navajo Reservation)	Rainbow trout Brown trout Brook trout
Big Gap Lake (Navajoa Reservation)	Rainbow trout Fathead minnow
Morgan Lake (Navajo Reservation)	Northern pike Carp Black bullhead Channel catfish Green sunfish Bluegill Largemouth bass

Table A5. (Continued)

Body of water	Species of fish
San Juan River (below Navajo Dam)	Cutthroat trout
	Rainbow trout
	Brown trout
	Carp
	Red shiner
	Fathead minnow
	Colorado squawfish
	Speckled dace
	Bluehead sucker
	Flannelmouth sucker
	Channel catfish
	Rio Grande killifish
	Mosquitofish
	Green sunfish
	Largemouth bass
	Mottled sculpin
Navajo Dam	Coho salmon
	Kokanee
	Rainbow trout
	Brown trout
	Northern pike
	Carp
	Roundtail chub
	Fathead minnow
	Speckled dace
	White sucker
	Bluehead sucker
	Flannelmouth sucker
	Black bullhead
	Channel catfish
	Green sunfish
	Bluegill
	Smallmouth bass
	Largemouth bass
	White crappie
	Mottled sculpin
Upper San Juan (above Navajo Dam)	Kokanee
	Rainbow trout
	Brown trout
	Carp
	Roundtail chub
	Fathead minnow
	Speckled dace
	White sucker

Table A5. (Continued)

Body of water	Species of fish
Upper San Juan (above Navajo Dam) (continued)	Bluehead sucker
	Flannelmouth sucker
	Black bullhead
	Channel catfish
	Green sunfish
	Smallmouth bass
	Largemouth bass
	Iowa darter
	Mottled sculpin
Cutter Lake (Navajo Reservation)	Rainbow trout
	Brown trout
	Black bullhead
	Bluegill
Berland, Aspen & Todachenee Lakes (Navajo Reservation)	Rainbow trout
Asaayi Lake (Navajo Reservation)	Rainbow trout
	Brook trout
	Fathead minnow
	Speckled dace
Bowl Creek (Navajo Reservation)	Rainbow trout
	Speckled dace
Whiskey Creek (Navajo Reservation)	Rainbow trout
	Brown trout
	Speckled dace
	Bluehead sucker
Wheatfields Creek (Navajo Reservation)	Rainbox x cutthroat trout
	Fathead minnow
	Bluehead sucker
Tsaile Lake (Navajo Reservation)	Cutthroat trout
	Rainbow trout
	Brook trout
	Fathead minnow
	Channel catfish
Round Rock Lake (Navajo Reservation)	Rainbow trout
	Fathead minnow
	Channel catfish

Table A5. (Continued)

Body of water	Species of fish
Red Lake (Navajo Reservation)	Rainbow trout Brown trout Northern pike Fathead minnow Black bullhead Channel catfish Largemouth bass
Sawmill and Trout Lakes (Navajo Reservation)	Rainbow trout
Knudson Lake (Ft. Wingate Depot Activity)	Rainbow trout Channel catfish
McFerrin Lake (Ft. Wingate Depot Activity)	Rainbow trout
Nutria # 2 and #4 Lakes (Zuni Pueblo)	Rainbow trout Fathead minnow
Rio Nutria (Zuni Pueblo)	Rainbow trout Fathead minnow Zuni mountain sucker Green sunfish Rio Grande killifish
Rio Pescado (Zuni Pueblo)	Fathead minnow Speckled dace Zuni mountain sucker Rio Grande killifish Green sunfish
Zuni River (Zuni Pueblo)	Fathead minnow Longfin dace Zuni mountain sucker Green Sunfish Rio Grande killifish
Black Rock Lake (Zuni Pueblo)	Rainbow trout Northern pike Fathead minnow Green sunfish Rio Grande killifish
Erustace Lake (Zuni Pueblo)	Northern pike Fathead minnow Channel catfish Green sunfish Rio Grande killifish Largemouth bass

Table A5. (Continued)

Body of water	Species of fish
Mancos River (Ute Mountain Ute Reservation)	Brown trout
	Roundtail chub
	Red shiner
	Fathead minnow
	Speckled dace
	Bluehead sucker
	Mosquitofish
Navajo Wash (Ute Mountain Ute Reservation)	Carp
	Roundtail chub
	Red shiner
	Fathead minnow
	Speckled dace
	Bluehead sucker
	Flannelmouth sucker
Bancroft, Pine Creek, and Horseshoe Reservoirs (Ute Mountain Ute Reservation)	Rainbow trout
Capote Lake (Southern Ute Reservation)	Rainbow trout
	Fathead minnow
	Black bullhead
Navajo River	Rainbow trout
	Brown trout
	Brook trout
	Rio Grande chub
	Roundtail chub
	Fathead minnow
	Speckled dace
	White sucker
	Bluehead sucker
	Flannelmouth sucker
	Black bullhead
	Mottled sculpin
Rio Blanco	Cutthroat trout
	Rainbow trout
	Brown trout
	Brook trout
	Speckled dace
	White sucker
	Bluehead sucker
	Flannelmouth sucker
	Mottled sculpin

Table A5. (Continued)

Body of water	Species of fish
Dulce Lake (Jicarilla Apache Reservation)	Rainbow trout Fathead minnow
Mundo Lake (Jicarilla Apache Reservation)	Rainbow trout Brown trout Fathead minnow
Farmington Lake	Rainbow trout White sucker Flannelmouth sucker Channel catfish Bluegill Largemouth bass White crappie
Farmington City Lake	Fathead minnow White sucker Flannelmouth sucker Black bullhead Channel catfish Bluegill Largemouth bass Mosquitofish
Jackson Lake	Rainbow trout Carp Fathead minnow Flannelmouth sucker Black bullhead Channel catfish Bluegill Largemouth bass White crappie Mosquitofish
Bluewater[a]	Coho salmon Rainbow trout Brown trout Rio Grande chub Fathead minnow Golden shiner White sucker Rio Grande sucker Channel catfish Largemouth bass Plains killifish

Table A5. (Continued)

Body of water	Species of fish
Animas River	Kokanee
	Cutthroat trout
	Rainbow trout
	Brown trout
	Brook trout
	Northern pike
	Fathead minnow
	Speckled dace
	White sucker
	Bluehad sucker
	Flannelmouth sucker
	Channel catfish
	Green sunfish
	Bluegill
	Largemouth bass
	Yellow perch
	Mottled sculpin
La Plata River	Cutthroat trout
	Rainbow trout
	Brown trout
	Brook trout
	Fathead minnow
	Speckled dace
	Bluehead sucker
	Flannelmouth sucker
	Mottled sculpin
Rio Chama	Kokanee
	Rainbow trout
	Brown trout
	Carp
	Rio Grande chub
	Flathead chub
	Fathead minnow
	Longnose dace
	White sucker
	Rio Grande sucker
	Channel catfish
El Vado Reservoir	Coho salmon
	Kokanee
	Rainbow trout
	Brown trout
	Carp
	Rio Grande chub

Table A5. (Continued)

Body of water	Species of fish
El Vado Reservoir (continued)	Flathead chub
	Fathead minnow
	Longnose dace
	White sucker
	Rio Grande sucker
	Channel catfish
Abiquiu Reservoir	Coho salmon
	Kokanee
	Rainbow trout
	Brown trout
	Carp
	Rio Grande chub
	Flathead chub
	Fathead minnow
	Longnose dace
	White sucker
	Rio Grande sucker
	Channel catfish
Los Pinos River	Rainbow trout
	Brown trout
	Carp
	Roundtail chub
	Fathead minnow
	Speckled dace
	White sucker
	Bluehad sucker
	Flannelmouth sucker
	Black bullhead
	Channel catfish
	Green sunfish
	Smallmouth bass
	Largemouth bass
Piedras River	Rainbow trout
	Brown trout
	Speckled dace
	White sucker
	Bluehad sucker
	Flannelmouth sucker
	Black bullhead
	Mottled sculpin

Table A5. (Concluded)

Body of water	Species of fish
Upper Dolores River (above Dolores, Colorado)	Cutthroat trout
	Rainbow trout
	Brown trout
	Brook trout
	Brassy minnow
	Fathead minnow
	Speckled dace
	Bluehead sucker
	Flannelmouth sucker
	Mottled sculpin
Lower Dolores River (below Dolores, Colorado)	Brown trout
	Carp
	Roundtail chub
	Brassy minnow
	Red shiner
	Fathead minnow
	Speckled dace
	Flannelmouth sucker
	Black bullhead
Heron Reservoir	Rainbow trout
	Carp
	White sucker

[a]Bluewater Lake was rotenoned in 1977 and stocked with coho salmon, rainbow trout, and channel catfish. Fathead minnows are the only other species confirmed since that time although it is possible that small numbers of the other species also survived.

Table A6. Common and scientific names of plants used in the report.[a]

Common Name	Scientific name
Grasses and grasslike plants	
Alkali sacaton	*Sporobolus airoides*
Arizona pescue	*Festuca arizonica*
Black grama	*Bouteloua eriopoda*
Blue grama	*Bouteloua gracilis*
Bluegrass	*Poa* sp.
Bottlebrush squirreltail	*Sitanion hystrix*
Bulrush	*Scirpus* sp.
Canada wildrye	*Elymus canadensis*
Cheatgrass	*Bromus tectorum*
Fairway wheatgrass	*Agropyron cristatum*
Fendler three-awn	*Aristida fendleriana*
Fescue	*Festuca* sp.
Foxtail barley	*Hordeum jubatum*
Galleta	*Hilaria jamesii*
Indain ricegrass	*Oryzopsis hymenoides*
Inland bluegrass	*Poa interior*
Junegrass	*Koleria cristata*
Kentucky bluegrass	*Poa pratensis*
Little bluestem	*Andropogon scoparius*
Mountain muhly	*Muhlenbergia montana*
Muhly	*Muhlenbergia arsenei*
Muttongrass	*Poa fendleriana*
Needle and thread	*Stipa comata*
New Mexico feathergrass	*Stipa neomexicana*
Oat grass	*Danthonia californica*
Pine dropseed	*Blepharoneuron tricholepis*
Red three-awn	*Aristida longiseta*
Ring muhly	*Muhlenbergia torreyi*
Sand dropseed	*Sporobolus cryptandrus*
Snad muhly	*Muhlenbergia arenicola*
Scratchgrass	*Muhlenbergia asperifolia*
Sedge	*Carex* sp.
Sideoats grama	*Bouteloua curtipendula*
Sixweeks fescue	*Festuca octoflora*
Sixweeks grama	*Tridens muticus*
Spike dropseed	*Sporobolus contractus*
Spikerush	*Eleocharis* sp.
Streambank wheatgrass	*Agropyron riparium*
Tumblegrass	*Schedonnardus paniculatus*
Western wheatgrass	*Agropyron smithii*
Wolftail	*Lycurus phleoides*

Table A6. (Continued)

Common Name	Scientific name
Forbs	
Aster	*Aster* sp.
Beardlip penstemon	*Penstemon barbatus*
Beardtongue	*Penstemon jamesii*
Bladderpod	*Lesquerella* sp.
Bladderwort	*Utricularia* sp.
Blackfoot daisy	*Melampodium leucanthum*
Bitterweed	*Hymenoxys odorata*
Buttercup	*Ranunculus* sp.
Cattail	*Typha latifolia*
Cinquefoil	*Potentilla* sp.
Coontail	*Ceratophyllum demersum*
Dock	*Rumex* sp.
Eriogonum	*Eriogonum* sp.
Fleabane	*Erigeron* sp.
Globemallow	*Sphaeralcea* sp.
Groundsel	*Senecio* sp.
Horsetail	*Equisetum* sp.
Loco	*Astragalus* sp.
Louisiana sagebrush	*Artemesia ludoviciana*
Lupine	*Lupinus* sp.
Milfoil	*Myriophyllum* sp.
Onion	*Allium* sp.
Paintbrush	*Castilleja* sp.
Penstemon	*Penstemon* sp.
Pingue	*Hymenoxys richardsoni*
Pond lily	*Nymphea* sp.
Rocky mountain beeweed	*Cleome serrulata*
Russian thistle	*Salsola kali*
Sagewort	*Artemesia campestris*
Silverleaf nightshade	*Solanum elaegnifolium*
Sunflower	*Helianthus* sp.
Tansymustard	*Descurainia* sp.
Threadleaf groundsel	*Senecio longilobus*
Violet	*Viola* sp.
Watershield	*Brasenia schrelberi*
Trees, shrubs, and woody vines	
Alligator juniper	*Juniperus deppeana*
Banana yucca	*Yucca baccata*
Beargrass	*Nolina microcarpa*
Big sagebrush	*Artemesia tridentata*
Bitterbrush	*Purshia tridentata*
Blueberry	*Vaccinium* sp.
Blue spruce	*Picea pungens*
Box elder	*Acer negundo*

Table A6. (Concluded)

Common Name	Scientific name
Trees, shrubs, and woody vines (continued)	
Broom snakeweed	Guiterrezia sarothrae
Cliffrose	Cowania mexicana
Coyote willow	Salix exigua
Douglas-fir	Pseudotsuga menziesii
Engelmann spruce	Picea engelmanni
Fineleaf yucca	Yucca angustissima
Fourwing saltbush	Atriplex canescens
Gambel oak	Quercus gambeli
Greasewood	Sarcobatus vermiculatus
Green ephedra	Ephedra viridis
Littleleaf mockorange	Philadelphus microphyllus
Limber pine	Pinus flexilis
Lodgepole pine	Pinus contorta
Mountain-mahogany	Cercocarpus montanus
One-seed juniper	Juniperus monosperma
Narrow-leaf cottonwood	Populus angustifolia
Pacific willow	Salix lasiandra
Pale wolfberry	Lycium pallidum
Peachleaf willow	Salix amygdaloides
Pinyon pine	Pinus edulis
Ponderosa pine	Pinus ponderosa
Prickly-pear	Opuntia sp.
Quaking aspen	Populus tremuloides
Rio Grande cottonwood	Populus wislizeni
Rocky Mountain juniper	Juniperus scopulorum
Rubber rabbitbrush	Chrysothamnus nauseosus
Russian olive	Eleagnus augustifolius
Salt cedar	Tamirix pentandra
Singleleaf pinyon	Pinus monophyllum
Skunkbush sumac	Rhus trilobata
Squaw currant	Ribes inebrians
Subalpine fir	Abies lasiocarpa
Utah juniper	Juniperus osteosperma
Utah serviceberry	Amelanchier utahensis
Virginbower	Clematis ligusticifolia
Virginia creeper	Parthenocissus inserta
Walkingstick cholla	Opuntia imbricata
Wavyleaf oak	Quercus undulata
White fir	Abies concolor
Willow	Salix sp.
Winterfat	Eurotia lanata

[a]Nomenclature follows Hitchcock (1950), Kearney and Peebles (1951), and Nickerson et al. (1976).

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13. Type of Report & Period Covered
Final

14.

15. Supplementary Notes
Report was presented to the Bureau of Indian Affairs as a working paper for the San Juan Basin in Regional Uranium Study.

16. Abstract (Limit: 200 words)

This report contains an identification of fish and wildlife species and their habitats within the San Juan Basin of New Mexico, Arizona and Colorado on Indian lands. Field inventories were taken on existing and proposed uranium development sites during the summer of 1979 to determine the distribution of wildlife species. These wildlife inventories gave an indication of species migration and emigration as associated with this type of mining activity. Based on development projections from the Bureau of Indian Affairs, scenarios were identified as to the potential impacts that may be realized if differing stages of uranium mining and milling are conducted. Recommendations were also drawn from the field analyses. This study demonstrated that some species benefited as a result of water impoundments, in the water discharge and fencing to restrict grazing activity from the site. The effects that radionuclides may play in this role were identified, however it was not the scope of this report nor was funding available to complete tissue or bone analysis of individual fish and wildlife species.

17. Document Analysis a. Descriptors
Environmental impacts, Habitat, Uranium, Mining, Milling
Fish, Radionuclides, impoundments
Wildlife, mine water discharge, grazing, benefits
Inventory

b. Identifiers/Open-Ended Terms
New Mexico, Arizona, Colorado
San Juan Basin
Indian lands

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
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U. S. Department of the Interior

Fish and Wildlife Service

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.